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SCI-FI MOVIES RATED BY REAL SCIENTISTS! p. 82

Popular Mechanics

LIFTOFF

AMERICA ROARS BACK INTO SPACE

BIGGER MISSIONS

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NEW SPACECRAFT
p. 73



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U.S. SPACE TOURISM'S FIRST RIDE

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DRAGON-RIDER
ORBITS EARTH, DOCKS AT THE ISS

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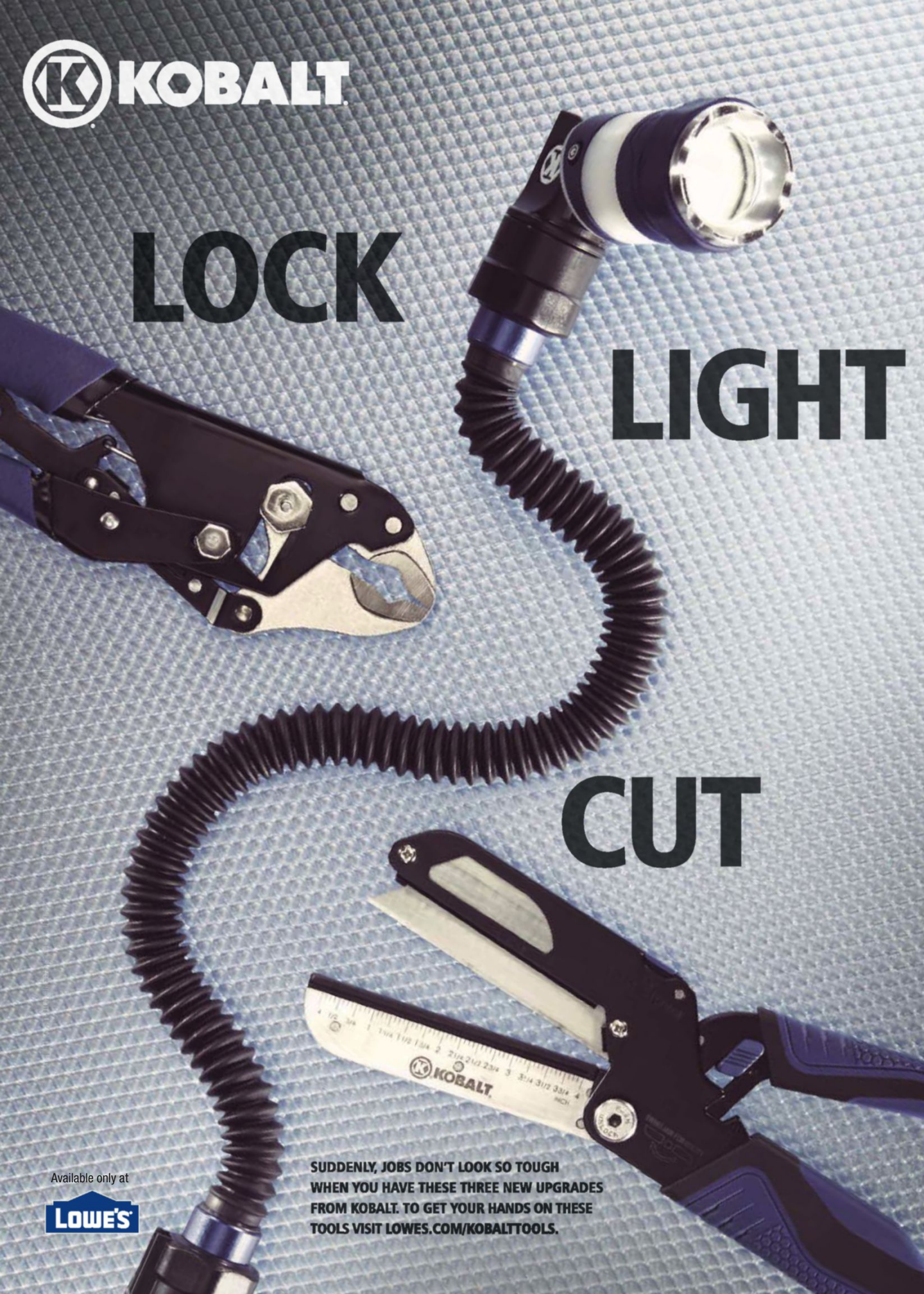
ISSUE
DECEMBER/ JANUARY 2014
Since 1902

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AUTO HOME TECH SCIENCE ADVENTURE


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PopMech

IGNITION

12.13
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It takes a really, really big hangar—like this one in Tustin, Calif.—to contain the 266-foot-long Aeroscraft airship.

ON THE COVER

Going up: SpaceX's Merlin engine (below, left) and Orbital Sciences' Antares rocket, photographed exclusively for POPULAR MECHANICS by Eric Ogden and Thom Baur, respectively.



The New Space Age | PopMech highlights seven spacecraft that are leading us into a new era of space exploration. Don't blink—it's launching sooner than you think. BY JEFF WISE 73

Scientist Approved! The 10 Best Sci-Fi Films Ever | Scientists and engineers pick the genre's top films. BY JOE PAPPALARDO 82

Ship of Dreams | Aeroscraft is nearly as long as a football field. But the fact that it might actually work—and not its size—is what sets it apart in airship history. BY KALEE THOMPSON 88

Ignition:
Letters, Complaints, Events 08

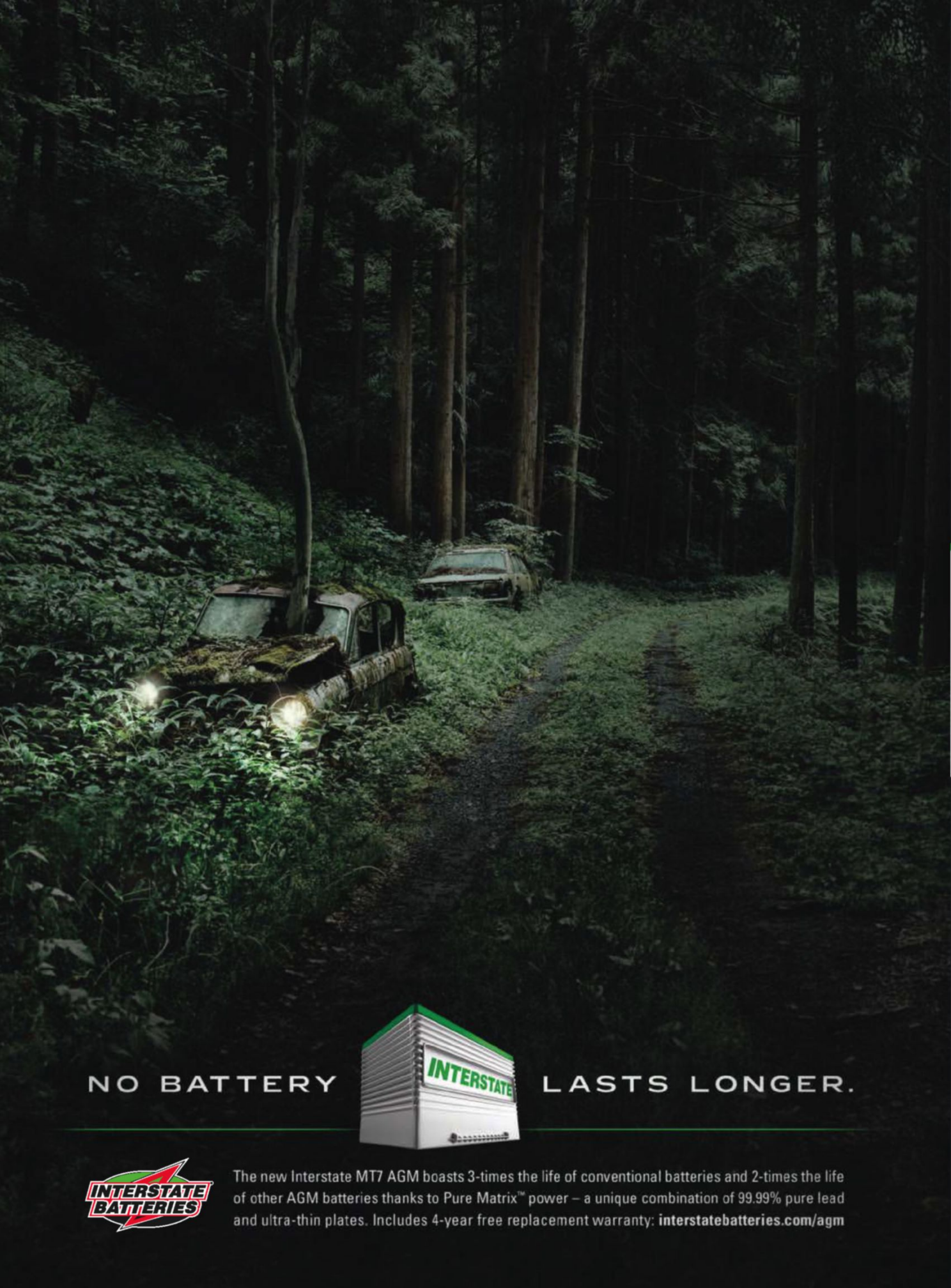
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From Maker Movement to New Industrial Revolution
Yesterday, makers were fringe characters. Today they're a cultural and economic force. Here is how they're doing it.
BY CHRIS ANDERSON 66

Mosaic Theory
Government and business entities are using digital tools to record our every move. Maybe it's time to turn the tables—and keep track of who is tracking us, and how.
BY GLENN HARLAN REYNOLDS ... 70


NO BATTERY
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The new Interstate MT7 AGM boasts 3-times the life of conventional batteries and 2-times the life of other AGM batteries thanks to Pure Matrix™ power – a unique combination of 99.99% pure lead and ultra-thin plates. Includes 4-year free replacement warranty: interstatebatteries.com/agm

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UNDER THE  GREEN ROOF

AGM BATTERIES LAST LONGER THAN TRADITIONAL FLOODED LEAD-ACID BATTERIES, AND THE MT7 AGM LASTS THE LONGEST. BUT, WHERE DOES IT GET ITS POWER? LIKE ALL AGMS, IT STARTS WITH ABSORBED GLASS MATS.

Absorbed glass what?

Absorbed glass mats–that's what AGM stands for. AGM batteries are lead-acid batteries that hold or suspend electrolytes in a highly-absorbent glass mat that acts as a separator material between the positive and negative plates.

What else is unique to AGMs?

Chemistry. Oxygen-recombination chemistry to be precise. Unlike traditional flooded lead-acid batteries, AGM batteries internally recombine hydrogen and oxygen to water so that very little gas is emitted externally.



HIGH VIBRATION RESISTANCE

Due to the AGM's unique internal assembly and physical design, its vibration resistance is normally higher than others available.



LOW INTERNAL RESISTANCE HIGH RECHARGE ACCEPTANCE

As a result of the AGM's oxygen-recombination chemistry, it doesn't use gas in the same way as flooded lead-acid batteries commonly do.



VALVE-REGULATED LEAD-ACID

AGM batteries are Valve-Regulated Lead-Acid or VRLA. In that, they do not have an open vent system like other flooded lead-acid batteries.

Are all AGM batteries created equal?

Not at all. Similar to flooded lead-acid batteries, there are various differences between AGM batteries. Interstate's MT7 battery is a Dual Stage Performance AGM, which has higher recharge characteristics and lower internal resistance than other AGMs. Also, due to their 99.99% lead purity level and ultra-thin plates, these batteries have 2- to 3-times longer life than other batteries.

What are the benefits of deep cycling?

Interstate's MT7 Dual Stage Performance AGM battery can produce 3- to 4-times more the amount of deep cycles than Single Stage AGMs due to the battery's active material density levels. Unless the AGM battery produces approximately 400 deep cycles at 80% depth of discharge (DOD) and 600-700 cycles at 50% DOD, then it is not a true deep cycle battery.

INTERSTATE BATTERIES

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To find a dealer near you, visit interstatebatteries.com/agm



96 Auto

Does your audio system need a tech boost? Go from outdated to upgraded in nine easy steps.
Car Clinic Prepare for travel in wicked winter weather with seven items every trunk should contain.

104 Home

Forget Barbies and Hot Wheels, and build your own playthings. Illustrator Brian LaRossa designs a one-of-a-kind DIY toy for your kid and the kid in you.
Tool Test Roy Berendsohn puts bench grinders through their paces and finds the best.
Home Clinic This January incandescent bulbs will make a mass exodus from store shelves. What you need to know about the future of home illumination; plus, other household tricks and tips.

120 Tech

Carrying keys is archaic. Embrace the digital lock and all the 21st-century perks that come with it.
Digital Clinic Not all tech plays nice. Are some of your wireless gadgets acting a little wonky? Check your frequencies.

136 A Brief History of the . . .

Sled. (Ho ho ho!)

Very cute, eh? p. 104

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What You Said

(ABOUT OUR OCTOBER ISSUE AND MORE)

We read all your comments, tweets, and letters. About halfway through the pile, we're glowing with pride. A little later, we still love you, but we really need a nap. ***Curated by Darren Orf***

In our October cover story ("How Not to Die"), writer Jeff Wise reveals 20 potentially lethal scenarios that hide in plain sight—and how to detect and avoid them. Many readers wrote to tell us that the feature was compelling and informative, while others thought some of the items fell short. ● "Jeff Wise tells us to avoid shark-infested waters," Bryan Chapman of Hartsburg, Mo., writes. "But he fails to define how many sharks in how large an area would constitute an infestation." Good point, but relax, you're safe in Missouri. ● In "When Can I Let Go of the Wheel?" we examine the inevitable arrival of the self-driving car. Apparently, not everyone is ready to leave the driver's seat. "Now carmakers want to take away the pleasure and responsibility of driving," Louis Kleber of Las Vegas writes. "Can you imagine the lawsuits!" Yes, we can. Is it too late to switch careers? ● "Since my arrival as a refugee in 1960 to the U.S., not only did Popular Mechanics teach me how to read and write English, it also kept me informed of everything from cars to spacecraft," Carl von Stockhausen of Paradise, Calif., writes. "What will the future bring for Popular Mechanics?" Only good things, we hope!



COMPLAINTS DEPARTMENT

This is definitely not the magazine my father read. So disappointed.
IVIE WALKER, LAS VEGAS


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Popular Mechanics BREAKTHROUGH AWARDS



Matt Tran on the electric board that won him and two partners an award.

On Oct. 22, Popular Mechanics celebrated the ninth annual Breakthrough Awards in New York, an event some have called a nerd prom. (We take that as a compliment.) Science, technology, and product-development innovators received richly deserved recognition for 20 innovations that are making the world a better place. Leadership Award winner Peter Diamandis, of the XPRIZE Foundation, joined winners who included the creators of networked quadrotors that will work in disaster relief, exoskeleton legs, desktop manufacturing machines, lifesaving medical tech, a pilotless jet, and more.







PM tech editor Davey Alba talks 3D printing with MakerBot CEO Bre Pettis. Right: PM editor-in-chief Jim Meigs with Wendy Schmidt, Peter Diamandis, PM publisher Michael Kuntz, and Hearst Men's Enthusiast Group senior VP Jack Essig.

PHOTOGRAPHS BY MATTHEW CARASELLA (TRAN, INNOVATIONS LOGO, MEIGS AND GROUP, DIAMANDIS, KUSHLEYEV), SARAH SHATZ (DAVEY AND PETTIS, MEIGS AND LUCKEY, COVER, SHEA AND BASF)



Alex Kushleyev, cofounder of KMel Robotics, admires his drone. Below, Meigs and 21-year-old Palmer Luckey, developer of the Oculus Rift 3D headset.

From left: Diamandis; Next-Gen BTA winner Meghan Shea (in blue) with Breakthrough Awards sponsor BASF's Ron Barry, Kathy Dennis, and Geoffrey Johnson.

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Employee of the Month

Executive editor **DAVID DUNBAR** spearheaded PopMechU, a webinar series that gives you all the tricks and tips needed to be prepared for any disaster situation.



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THE KID WANTS TO KNOW

Are you a kid with a question? Ask Darren! Email popularmechanics@hearst.com.



How close are scientists to achieving cold fusion?

Grayson E., 13, Atlanta

Cold fusion aims to re-create at room temperature the process that occurs naturally in the sun, when atomic nuclei collide and fuse in very high heat. Scientists have achieved fusion with neutron generators, but it's not sustainable. "True cold fusion, in which the energy released is greater than the energy used to make it happen, is still a dream," says Richard A. Muller, a physics professor at the University of California, Berkeley. — *DARREN ORF*

ILLUSTRATION BY MARTIN LAKSMAN (EMPLOYEE OF THE MONTH)

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The results have landed. Which team soared to victory?

The winner: Inspiration Labs, taking home this year's prize of $1000. The Police Callbox Lander combines a 1980s arcade game with 21st-century mind control and houses it all in a full-sized replica London police phone box.







Police Callbox Lander (A Biofeedback–Controlled Game)

Inspiration Labs | Tampa, Florida

This year's theme — from something old, make something new — led the scrappy Florida-based team to update the classic arcade game Lunar Lander. In it, a player tries to safely land a spacecraft on the inhospitable surface of the moon. But there's a twist: a scavenged EEG (electroencephalography) device forces him to control the amount of thrust through the power of his mind. To check out the project and videos, visit popmechnow.com/radioshack.

RadioShack would like to thank runner-up Milwaukee Makerspace. Their contraption, the Milwaukee Makerspace Morgifying Marble Manipulation Machine (aka M^6), takes a marble on a roller-coaster tour of the workshop in Brew City.

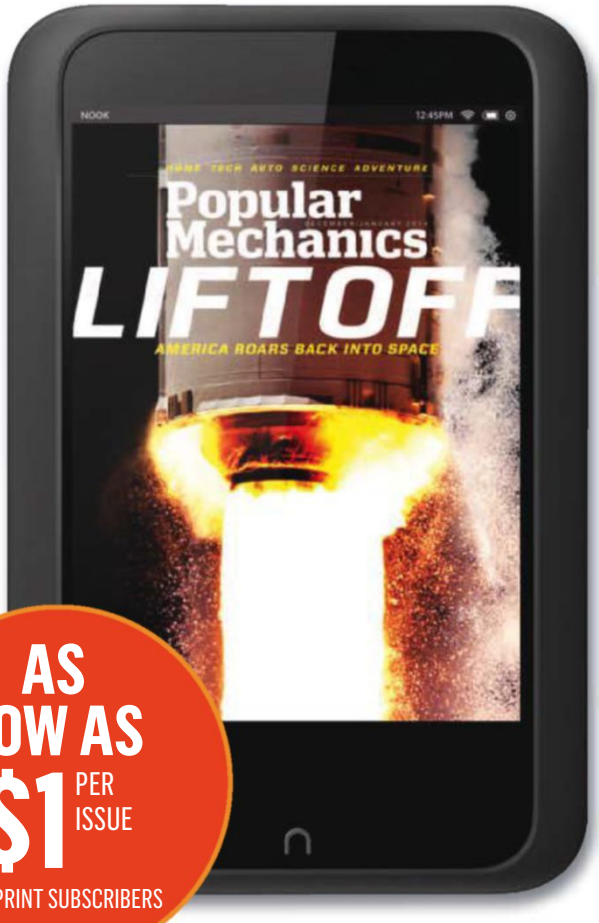
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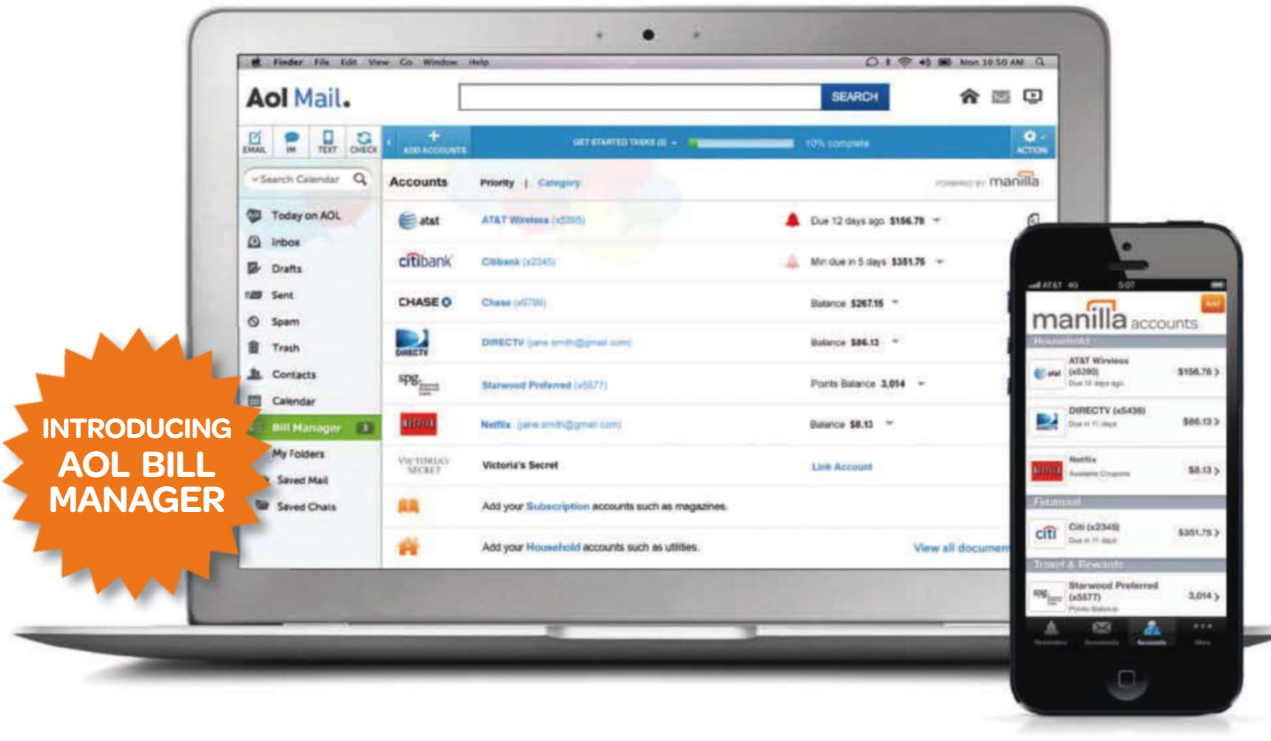
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Tech WATCH

NEWS
TRENDS
BREAKTHROUGHS

Edited by
JENNINGS BROWN

1



Battle of the Lifesaving Robots

In late December there will be a gathering of androids, some of the most ambitious disaster-response robots ever devised, at a speedway outside →

MEET THE TEAMS

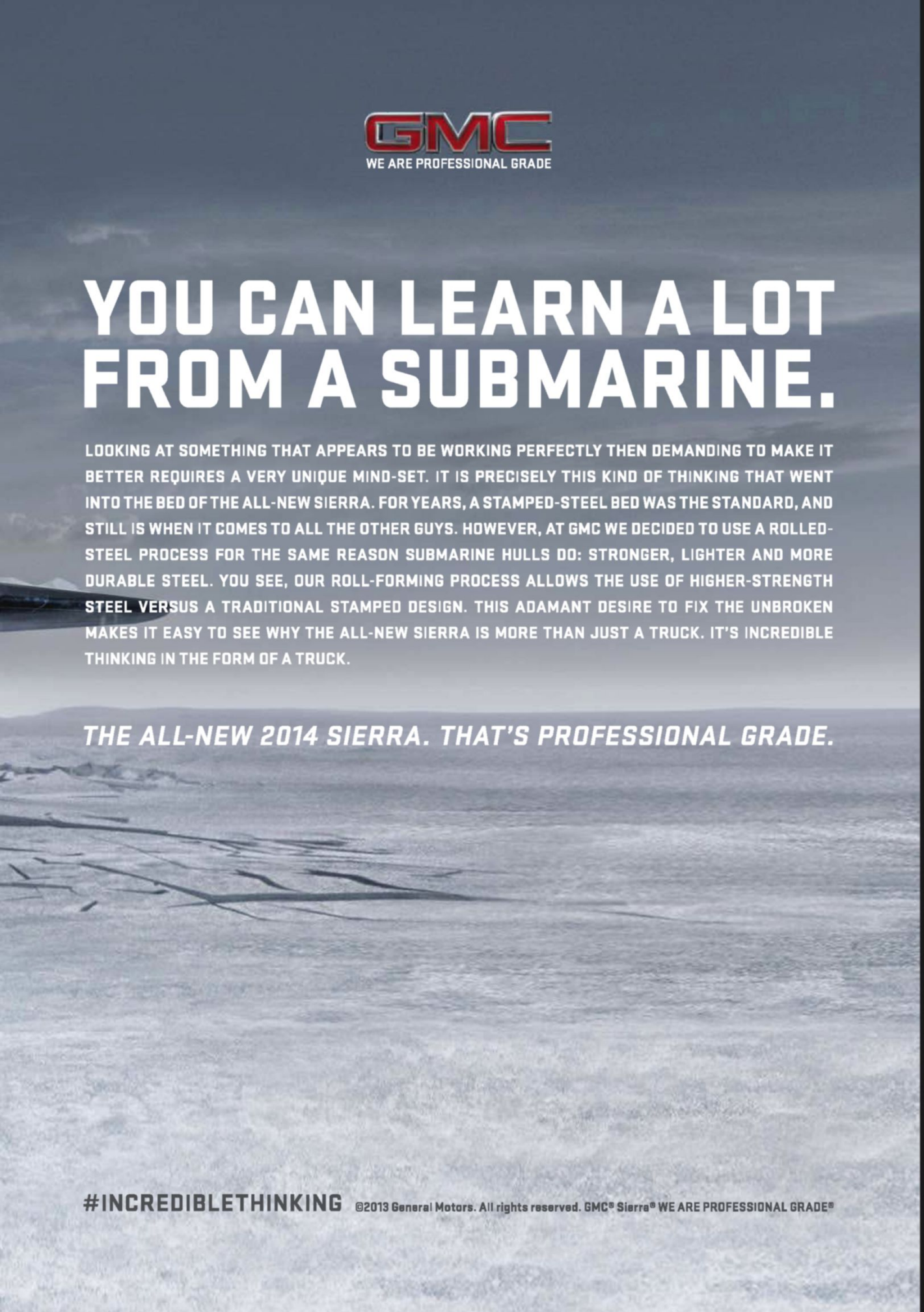
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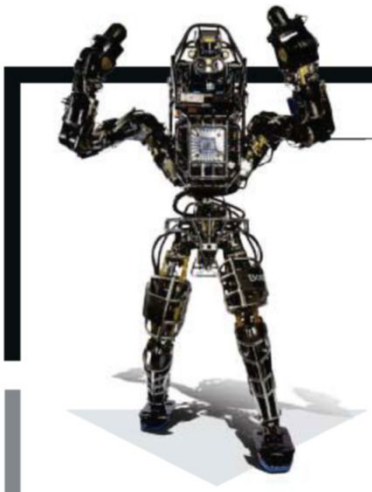
ROBOT: **Atlas**
TEAMS: **Seven. The challenge is open to software programmers, so DARPA gave each team its own Atlas.**
RUNDOWN: **This 6.2-ft 330-lb robot made by Boston Dynamics has 28 hydraulically actuated joints and a laser radar guidance package installed in its head.**



ILLUSTRATION BY MARTIN LAKSMAN


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LOOKING AT SOMETHING THAT APPEARS TO BE WORKING PERFECTLY THEN DEMANDING TO MAKE IT BETTER REQUIRES A VERY UNIQUE MIND-SET. IT IS PRECISELY THIS KIND OF THINKING THAT WENT INTO THE BED OF THE ALL-NEW SIERRA. FOR YEARS, A STAMPED-STEEL BED WAS THE STANDARD, AND STILL IS WHEN IT COMES TO ALL THE OTHER GUYS. HOWEVER, AT GMC WE DECIDED TO USE A ROLLED-STEEL PROCESS FOR THE SAME REASON SUBMARINE HULLS DO: STRONGER, LIGHTER AND MORE DURABLE STEEL. YOU SEE, OUR ROLL-FORMING PROCESS ALLOWS THE USE OF HIGHER-STRENGTH STEEL VERSUS A TRADITIONAL STAMPED DESIGN. THIS ADAMANT DESIRE TO FIX THE UNBROKEN MAKES IT EASY TO SEE WHY THE ALL-NEW SIERRA IS MORE THAN JUST A TRUCK. IT'S INCREDIBLE THINKING IN THE FORM OF A TRUCK.
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Miami. More than a dozen teams will pit their designs against each other's to win the DARPA Robotics Challenge (DRC).

Today's disaster-response robots are limited by where they can go and by what they can do when they get there. "The world is built for human beings," says DARPA program manager Gill Pratt. "Robots need to operate in that environment." During the Fukushima Dai-ichi nuclear reactor accident in Japan, for example, wheeled robots needed time-consuming adaptations to be able to climb stairs, and in contaminated areas could do nothing but stare at valves that could have been shut to limit the release of radiation.

The DRC requires contending androids to navigate complicated terrain, climb a ladder, operate human tools, and drive a human vehicle. The first trials this December, which are open to the public, will allow teams to operate bots on tethers, but later contests will call for the machines to operate autonomously. Final trials are planned for December 2014.

— *JOE PAPPALARDO*



EARTH PHENOMENON

Volcano Watch

1 Screaming Volcanoes

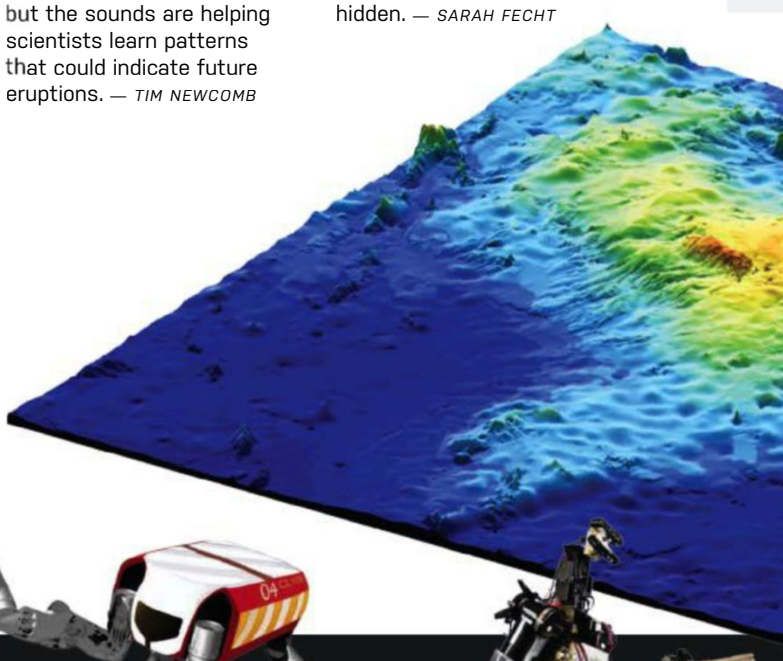
Alaska's Redoubt Volcano screams at us. And the height of its "harmonic tremor" reaches into the lower limits of human hearing. As the volcano, 110 miles southwest of Anchorage, nears eruption, earthquakes pile up. The sounds from inside build with the pressure, gliding up to a higher frequency until pausing before Redoubt explodes. Harmonic tremors are common, but most don't rise above 3 Hz (humans can hear 20 Hz). Redoubt can climb all the way to 30 Hz. Screams from Redoubt don't give enough warning for local evacuation, but the sounds are helping scientists learn patterns that could indicate future eruptions. — *TIM NEWCOMB*

2 Deep-Sea Monster

In the depths of the Pacific, 990 miles off the coast of Japan, scientists have discovered a 2.8-mile-high volcano. New research reveals that its slopes, previously thought to be made of the lava of multiple volcanoes, were formed from the lava of a single source. That would make Tamu Massif the largest volcano on the planet. Its estimated 120,000-square-mile area dwarfs the previous record holder, the 2000-square-mile Mauna Loa. And since much of Earth's oceans has yet to be mapped, it's possible that more mega-volcanoes remain hidden. — *SARAH FECHT*

3 Pr… Er…









HERE ARE A FEW OF THE TEAMS COMPETING IN THE FIRST ROUND OF THE DARPA ROBOTICS CHALLENGE IN FLORIDA.

ROBOT: **RoboSimian** ***TEAM:*** **NASA's Jet Propulsion Lab**
RUNDOWN: **No one said the robots had to mimic humans exactly. NASA designed "an apelike disaster-recovery robot" with a squat profile that emphasizes stability over speed.**

ROBOT:
TEAM: **D…**
RUNDO…
to a smartp… each devel… various tas… our robot d…

PHOTOGRAPHS BY GETTY IMAGES (REDOUBT VOLCANO), IODP (TAMU MASSIF VOLCANO), JPL-CALTECH (ROBOSIMIAN); ICONS BY MARTIN LAKSMAN

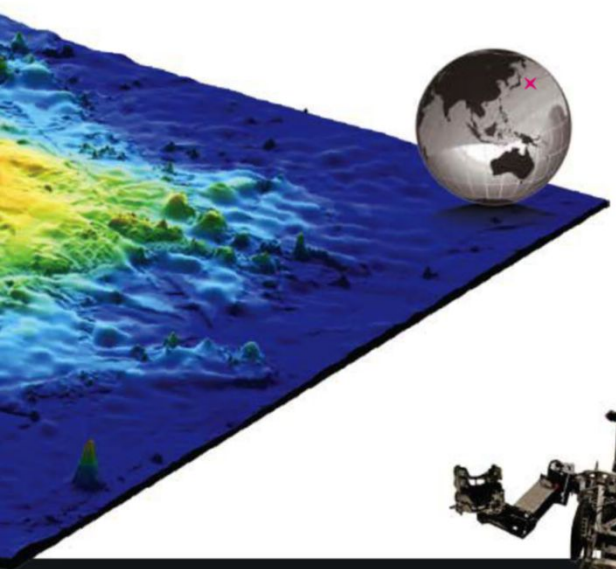


redicting
ruptions

SATELLITES: Two proposed satellite missions—one from NASA with a launch date of 2021, the other from the German Aerospace Center, which has no set dates—will collect data on surface deformations that occur before volcanic outbursts.

BURPS AND SIGHS: Volcano cores bubble with water vapor and gases. Oftentimes the gas burps free, releasing internal pressure. But when gas gets trapped inside magma, it can trigger violent eruptions. Researchers at Yale are creating models of gas buildup cycles that will help predict blasts.

MIXING MAGMA: In the past 700,000 years the Las Cañadas volcano in the Canary Islands has produced at least eight eruptions—the smallest of which spewed over 25 times more material than Iceland's 2010 Eyjafjallajökull eruption, which shut down air travel over the Atlantic. To understand what triggers such large-scale eruptions, UK researchers from the University of Southampton are studying crystallized magma. They found that the mixing of younger hot magma and older cold magma inside the volcano appeared to be a trigger for Las Cañadas' massive eruptions, much like how mixing hot air and cold air triggers thunderstorms. — *S.F.*

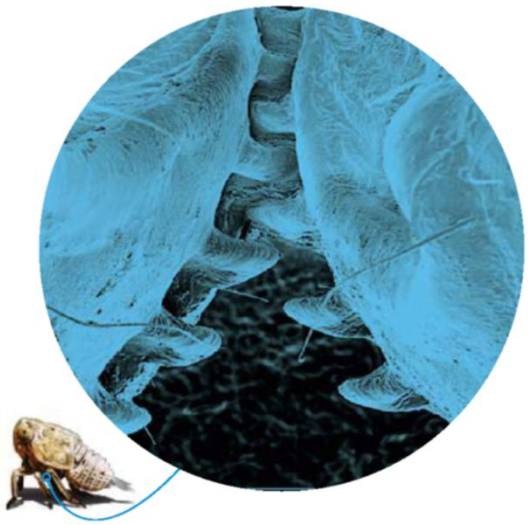


NATURE DISCOVERY

A Clockwork Insect

Meet the *Issus* nymph, a bug with a jump so fast it outpaces its own nervous system. This summer a duo of scientists discovered that it sports the first mechanical gear ever found in a living creature. But gears are only one of the bug's many marvels. "Put them all together," says Gregory Sutton, codiscoverer at the University of Bristol, "and you've got the design for a jumping robot."

— *WILLIAM HERKEWITZ*



MECHANICAL GEARS // Two gears step in for the Issus's brain to keep the insect's bulleting legs in sync during takeoff. With teeth shaped like cresting waves, the gears are unlike anything man-made. And stranger still, the bug doesn't keep its cogwheels forever. The gears disappear when it finishes its final molt and enters adulthood; researchers don't yet know why.

SPINAL SEATBELT // To keep its brain and nerve cord from liquefying during the sudden acceleration of a jump, the Issus has them strapped against its body with pegs of exoskeleton. "This isn't the smartest animal in the world," says Sutton, "but what it's got is plastered down."

COMPOSITE SPRINGS // To achieve its split-second acceleration, the Issus flicks its legs open with a pair of powerful springs. Arched and layered like two composite bows, the springs are made of resilin—nature's springiest material—coated with a stiff skeletal shell. The combination gives the bug its extreme bounce with little or no slack.

TECH WATCH



Hubo
RC-Hubo
WN: **Designers compare this 4.7-ft 120-lb android phone. Eight universities, with Drexel as lead, are oping an application to control the robot as it does sks. "You want vehicle driving, load that app, and rives the utility vehicle," the team's website reads.**

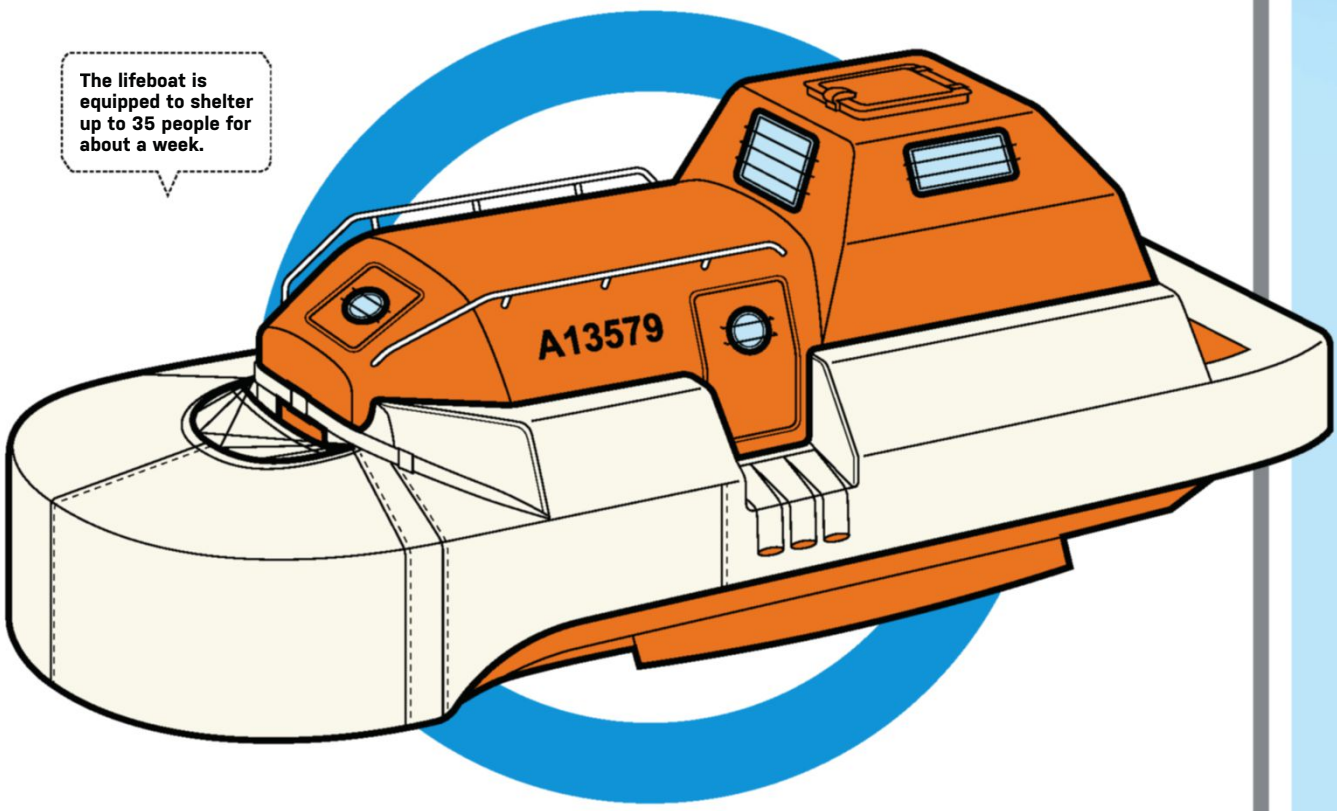
ROBOT: **THOR (Tactical Hazardous Operations Robot)**
TEAM: **Virginia Tech**
RUNDOWN: **Even the toughest robots need to be flexible. Elastic linear actuators drive this 5.6-ft robot's lower limbs, but it uses stiffer industrial-grade servos in its upper body.**

 ILLUSTRATION BY **PHIL LAUGHLIN**

DISASTER PREP

Tsunami Lifeboat

THOSE WHO CAN'T OUTRUN AN INCOMING TSUNAMI MIGHT FIND SAFETY IN THIS MODERN NOAH'S ARK–STYLE CRAFT. — *ALEX HUTCHINSON*



The lifeboat is equipped to shelter up to 35 people for about a week.

Japanese shipbuilder IHI Corporation recently completed safety tests on a 27-foot-long prototype.

Plans call for the lifeboats to be situated at strategic points in coastline communities.

The cushioning material encompassing the hull is designed to crumple and absorb shock upon collision.

The boat has demonstrated its ability to automatically right itself after capsizing.

WILL IT WORK? THIS LIFEBOAT SHOULD SURVIVE MOST TSUNAMIS, BUT PERHAPS NO VESSEL CAN STAND UP TO THE STRONGEST FORCES OF NATURE.

Height from which boat was drop-tested onto concrete:

16 FEET

Expected height of mega-tsunamis:

50 FEET

Largest wave recorded after magnitude 9.0 earthquake off Japan's coast in 2011:

124 FEET

ARCHITECTURE

Beware the Fryscrapers

Imagine approaching your Jaguar to find it vandalized, then turning around to see the culprit looming above. When Martin Lindsay returned to his XJ after stepping away for an hour, he found panels warped by heat reflecting off the nearby 20 Fenchurch Street "Walkie Talkie" skyscraper in London. But this 37-story building is just the newest reflective, concave structure capable of focusing the sun to cause such heat that it can melt plastic and singe hair. — *T.N.*

VDARA HOTEL
Las Vegas, 2009, architect Rafael Viñoly

WALT DISNEY CONCERT HALL
Los Angeles, 2003, architect Frank Gehry



KILLER CURVES
Call it a death ray. Or simply solar convergence phenomenon. These three buildings feature concave designs that, when the sun hits the right point in the sky, reflect the light into one focused beam. The Vdara's critical point is a sun angle of 71.5 degrees to the building, so for about an hour and a half each day the building acts as a giant magnifying mirror.

STREET READINGS
University of Southern California research shows ground temps could reach 140 F at the Walt Disney Concert Hall, but lightweight materials in the path of the glare hit 300 F. German researchers found the Vdara can heat the ground to above 230 F and thin, dark items, such as a shopping bag, to over 400 F.

UPPING THE SHINE
Efforts to keep interiors energy efficient have designers (London, Las Vegas) using more reflective glass—up to 40 percent reflectivity, while typical clear glass is at 9. Gehry's desire for contrast features reflective polished steel.

PLANNING AHEAD
Gehry blamed installation of the steel panels at different angles than designed. Walkie Talkie is the second building Viñoly designed that melts nearby objects (he declined comment), but London developers say extensive analysis and pre-building modeling didn't show the street-level issues. They installed a protective scaffolding screen on the pavement, and are working on long-term solutions.

WALKIE TALKIE
London, May 2014, architect Rafael Viñoly



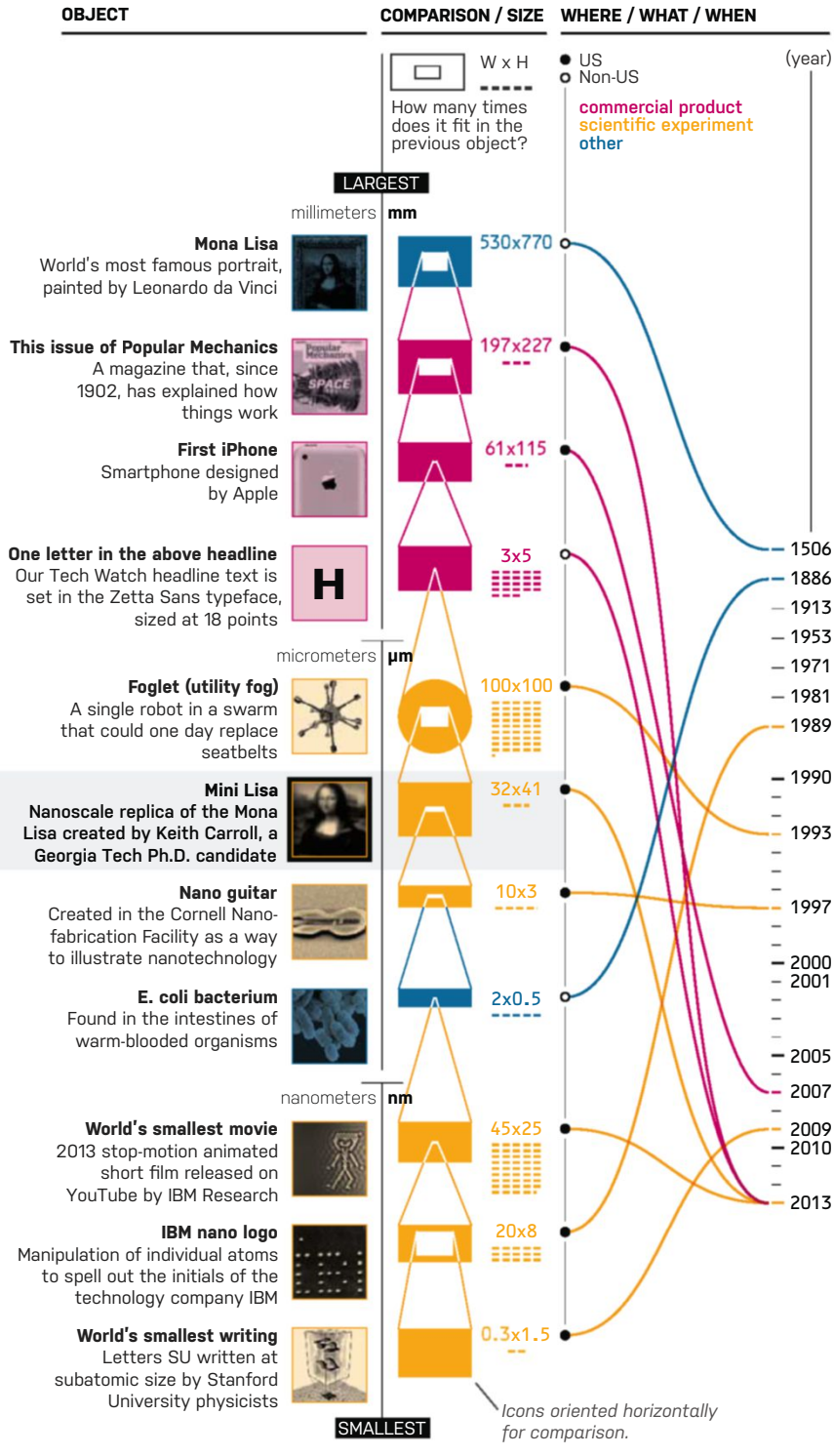
PHOTOGRAPHS BY GETTY IMAGES (VDARA, DISNEY HALL), ALAMY (WALKIE TALKIE); DIAGRAM BY MARTIN LAKSMAN

NANOTECHNOLOGY

How Small Is Small?

TECH WATCH

How to read it:

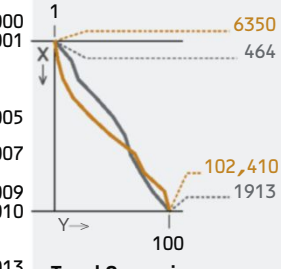


NANO ART HAS COME A long way since researchers arranged atoms to spell IBM in 1989. The latest feat is Mini Lisa, a detailed grayscale version of the *Mona Lisa* on a canvas just 32 microns across—one-third the width of a hair. The image was created with a new technique in which the heated tip of a powerful microscope controls the speed of a chemical reaction at each pixel: More heat produces a faster reaction and the lighter shade of gray. Below and to the left we show where the Mini Lisa fits on the nanoscale. The visualization compares 11 items, showing just how small each one is in comparison with the object above.

— *A.H.*

BIG INTEREST IN SMALL TECH

Funding and research in nanotech has grown exponentially in the last decade.*



Trend Comparison
Index 1/100

Federal yearly investment in National Nanotechnology Initiative, without American Recovery and Reinvestment Act funds (mil $).

Number of scientific articles on nanotechnology

*Graph rotated to correlate with time line

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*In digital cameras vs. Energizer MAX®. Results vary by camera. **Use less batteries, create less waste.



Upgrade

GEAR
TOOLS
GADGETS

WIN THIS!

Items worth a total of $1970 in this section could be yours for free! Look for the WIN THIS! *flag, and see p. 50 for info on how to enter the sweepstakes.*

GEAR AND GADGET GUIDE

Edited by **JENNINGS BROWN** • *Photographs by* **PHILIP FRIEDMAN**

Take our word for it, PopMech readers are a picky lot. And that makes you nearly impossible to shop for. Well, we've made your and your loved ones' lives easier by compiling a list of the most coveted products. Our editors toiled for months, playing with tons of toys, tools, gear, and gadgets. Then we brought in a team of master's candidates from the Industrial Design program at Pratt Institute in Brooklyn, N.Y., to help us cull the final batch.

By David Agrell, Rachel Z. Arndt, Roy Berendsohn, Jennings Brown, Amanda Green, Jaime Netzer, and Erik Sofge
Wardrobe styling by Eric Launder, grooming by Cindy Adams

ERIC LAUNDER, CINDY ADAMS/HALLEY RESOURCES

ASLI OZCIVELEK

"The design is clever. I can take photos with the camera attached to my phone or remove the lens and shoot from unusual angles."



SONY QX LENS-STYLE CAMERA, $250
Use your smartphone for what it's photographically best at: being a viewfinder and sharing photos. This lens attachment, which contains the same guts as Sony's high-end RX100 point-and-shoot, clips onto a smartphone and connects to it via Wi-Fi or NFC.

MORE GIFT GUIDE!

Download the PopMech iPad app and click the Specials tab to find a free, expanded Gift Guide with 50 more fantastic gift ideas. It has a click-to-buy feature, for hassle-free holiday shopping. And you can enter to win seven prizes.



KELTY TRAILOGIC COLLECTION SUPERLIGHT HIKING GEAR: BACKPACK, $200 SLEEPING BAG, $300 TENT, $300 CAMPING PAD, $80
No need to raid REI. This lightweight collection includes a sleeping bag, camping pad, and tent that all fit into a pack with easy-access compartments, an intuitive organization system, and advanced suspension. It's the ultimate starter kit for outdoor adventurers.



SONY XPERIA TABLET Z, $500–$600
Read or stream in the hot tub. This panel runs Android, sports a 1920 x 1200 resolution screen, and is completely waterproof.

GARMIN HEAD-UP DISPLAY, $130
Garmin's Head-Up Display (HUD) keeps eyes on the road by projecting navigation information from your smartphone onto your windshield.





KEN ONION WORK SHARP KNIFE & TOOL SHARPENER, $150
Renowned knifemaker Ken Onion helped design this electric sharpener that can tune any edge tool in your home, whether it's a hatchet, a shovel, or a sushi knife.

ASLI OZCIVELEK: JACKET BY LEVI'S, TENT AND BACKPACK STYLING CLAIRE TEDALDI/HALLEY RESOURCES

BEST GEAR & GADGETS

UPGRADE

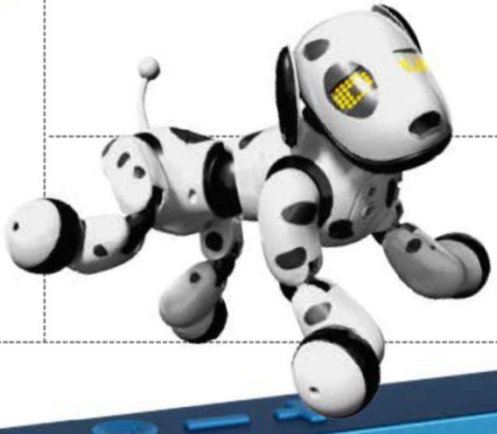


BRAUN COOLTEC, $200
Nip razor burn once and for all. Braun CoolTec soothes skin as you shave with an aluminum cooling bar, no creams or gels necessary.



WEBER ONE-TOUCH GOLD, $160
The classic Weber kettle grill gets even more well-done with a One-Touch cleaning system and a hinged cooking grate that offers 363 square inches of cooking space.

KETTLE PIZZA, $150
Transform just about any kettle charcoal grill into a gourmet pizza oven with this stainless-steel sleeve that fits between the lid and kettle-grill bottom.



ZOOMER ROBOT DOG, $100
Kids asking for a dog? Throw them a bone with a robotic equivalent. Zoomer can be trained to react to about 30 different voice commands. It's also the PopMech office's new mascot.



JAWBONE MINI JAMBOX, $180
Though it's only half the size of its big brother, the original Jambox speaker, the new mini version pumps out expansive, well-balanced, crisp music, thanks to its digital-signal-processing algorithms that adapt to volume changes.

VIRGIL CALEJESAN: SHIRT BY ERNEST ALEXANDER; JEANS BY RALPH LAUREN DENIM & SUPPLY



VIRGIL CALEJESAN

"I like that it has ports for remote control via computer and for attaching a digital camera—very cool and in line with today's feature-rich technology."

WIN THIS!

CELESTRON NEXSTAR 4SE COMPUTERIZED TELESCOPE, $500

Celestron makes the best amateur telescopes at moderate prices. This model is a hybrid (which means it uses features of both reflectors and refractors) that can automatically seek out 40,000 heavenly objects from its computer database.



GRADO SR80I HEADPHONES, $100
John Grado of Grado Labs designs all his headphones by listening, not by measuring. The result is the best pair of $100 headphones we've tried, with crisp midrange and treble, and tempered but powerful bass.

JENNIFER TATE

"I didn't expect the sound quality of plastic headphones to be great, but it is. I call the aesthetic new vintage—a fresh product with retro style."



KAMMOK ROO CAMPING HAMMOCK, $100
Set up for slumber wherever you darn well please. This ripstop hammock fits into a cantaloupe-size compression sack.



GOPRO HERO3+, $400
The next iteration of the leading personal hi-def adventure cam delivers images that are 33 percent sharper in a package that's 20 percent smaller and has 25 percent longer battery life. Pretty soon, we're guessing, you'll be carrying one in your wallet.



DREMEL MOTO-SAW, $100
Mount it on a bench and it's a scroll saw. Pick it up and it's a powered coping saw. Either way, it handles detailed cuts in wood, plastic, laminates, and metal.

JENNIFER TATE: SWEATER BY WOOLRICH. VEST BY BARBOUR FOR ORVIS. PANTS BY LEVI'S MADE & CRAFTED; HAMMOCK STYLING CLAIRE TEDALDI/HALLEY RESOURCES

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UPGRADE

BRADLEY FERRADA

"They actually remind me of Rock 'Em, Sock 'Em Robots, but the controls are just like a video game's—only translated to a physical toy."



COMBAT CREATURES ATTACKNIDS, $80 EACH
These surprisingly responsive and agile sci-fi-worthy bots encourage hands-on strategic thinking skills and a love of robotics. If you're lucky, your kid might even let you play.

SHENXING LIU

"The colors are like old video-game characters'. For me, these could be a pet—an electronic, remote-controlled pet."

WIN THIS!



VIZIO 5.1 HOME THEATER WITH SUBWOOFER, $360
Ditch the home theater setups (and tangle of cords) for Vizio's 5.1: a traditional sound bar that gains impressive surround sound with two satellite speakers wired to a subwoofer.

SHENXING LIU: SWEATER BY PENGUIN. PANTS BY RALPH LAUREN DENIM & SUPPLY. BRADLEY FERRADO: SHIRT BY WOOLRICH. PANTS BY DOCKERS


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Prototype shown with options. Production model may vary. ©2013 Toyota Motor Sales, U.S.A., Inc.
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Let's Go Places

UPGRADE



THULE EASY-FIT CU-9 SNOW CHAINS, $450
Snow chains used to be such a hassle that few people bothered. It took us less than a minute to pop the Easy-fit onto one wheel. Keep in mind, you should use them only for short distances.



TUBE-WRINGER 401 HEAVY DUTY, $22
This wringing wonder made by the Gill Mechanical Company disgorges every last drop of toothpaste (or adhesive) from the tube with a twist of the steel handle.



THE NORTH FACE THERMOBALL, $200
ThermoBall's innovative synthetic insulation, which has ball-like fibers instead of the usual long strands, is far lighter than other synthetics, and stays warm even when wet.

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*versus standard combination wrenches.



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UPGRADE

AREAWARE RADIO DOCK, $40
Created by industrial designer Jonas Damon, this brass-handled beech dock turns your iPhone 4 or 5 into an old-school radio. But it's not just for looks—the wood warms up the sound coming from your phone's speakers.



JUSTIN CROCKER

"I like the brass and wood, and the clean lines. It's a cool pairing of analog and digital. It provides the iPhone a stand and gives it context in your home."

JUSTIN CROCKER: SHIRT BY GANT RUGGER, JACKET BY LEE, PANTS BY WOOLRICH

Check Engine Light?

GoPoint Technology BT1 Wireless Tool and App

Know what's going on with your vehicle before you take it to the mechanic. Or better yet save yourself a trip and hundreds of dollars! GoPoint Technology's BT1 Wireless Tool works with your Apple iPhone, iPod touch, iPad and Android to remove the risks and surprises from driving. Simply plug the BT1 into your vehicle and download the app to access check engine light data and translate error codes. Retrieves service bulletins, safety recalls, analyzes fuel consumption relative to driving habits and more! Works on 1996 MY vehicles and newer. See our website for more apps.*



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A.Stone

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JJ72905

"**This product is great.** Now I don't have to call a mechanic everytime the car feels like its running funny. I can check it myself."

ELover08

"I've been getting a check engine light that comes and goes. I connected my iPod and it found a problem with one of the oxygen sensor heater circuits. It turned out to be a poor electrical connection. I was able to **repair it myself and avoid a hefty mechanic's bill**! I would say it paid for itself right out of the box!"

Tom7601

GOPOINT TECHNOLOGY

Bluetooth

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UPGRADE



WIN THIS!

BELKIN DYLE MOBILE TV RECEIVER, $150
The portable TV is back—in the form of a smartphone attachment. The Dyle, complete with retractable antenna, picks up old-fashioned over-the-air programming and displays it on iPhones and iPads.



KAUFMANN MERCANTILE RED METAL TOOL BOX, $28
This box is built tough, not tinny. And it's deceptively roomy. In fact, it's got just enough space to pack all the necessities when your folks want you to come over and help with their punch list.



TISSOT T-TOUCH EXPERT, $975–$1175
With a touchscreen altimeter, chronograph, compass, thermometer, and barometer, in addition to the usual features, the Tissot T-Touch Expert puts technology at an outdoorsman's fingertips.





TERN JOE D24 FOLDING BIKE, $650
Easier to fold than a T-shirt and equipped with a DoubleTruss frame and pothole-conquering Schwalbe Big Apple tires, the Joe D24 is the ultimate urban commuter.

For projects big or small, there's Mechanix Wear.





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M-PACT 4X®

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UPGRADE



PLAYSTATION 4, $400 VS XBOX ONE, $500

The console wars are raging once again, with Sony's new PlayStation 4 (PS4) facing off against Microsoft's Xbox One (XB1) for the hearts and wallets of gamers. The latest PlayStation and Xbox have more in common than ever: Both feature an AMD GPU and eight-core CPU, plus a hefty 8 GB of built-in RAM. So which one deserves your affection (and your greenbacks)? For now, that comes down to one question: Do you love football?

Most of the XB1's unique features are related to live TV—the console has an HDMI port for interacting with video piped in from your set-top cable or satellite box. This means one thing: an enhanced NFL experience, with access to scores, highlights, and the status of your registered fantasy football team. The console also responds to voice and gesture commands (it comes with a Kinect 3D camera), adding a dose of *Minority Report* to *Monday Night Football.*

Bottom line, the XB1 is more machine but will cost you more. In addition to the $100-higher price tag, online access, via Xbox Live, runs another $60 annually (Sony charges $50, but only for online multiplayer gaming). Whether that's a prohibitive premium or a price worth paying for a first glimpse of TV's future, well, that's between you and your team.

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BEST GEAR & GADGETS

UPGRADE

WIN THIS!



DYSON DC47 ANIMAL CANISTER VACUUM, $450
The bagless DC47 hits the sweet spot of vacuum cleaners: It's lightweight and easy to maneuver. And it's powerful—blowing away previous models, thanks to its two tiers of cyclones that work together to double the suction.



WOLVERINE ROCKFORD 1000 MILE BOOTS, $395
Pricey, yes. But you'll get your money's worth with these American-made work boots that you could wear on a date.



MIRI BERGER

"I'm a tool junkie, so this is heaven for me. The thick ratchet handles fit my hand, and the universal joint adapter helps with work in tight spaces."

DEWALT SAE/METRIC MECHANICS TOOL SET, $300
Oh, boy: 204 pieces of chrome-plated bliss. The set has laser-etched size markings, a minimal 5-degree arc swing on its ratchet wrenches, and a hardy blow-molded case that closes like a vault, thanks to four heavy clasps.

MIRI BERGER: SHIRT AND VEST BY ORVIS. BOOTS BY TOMS

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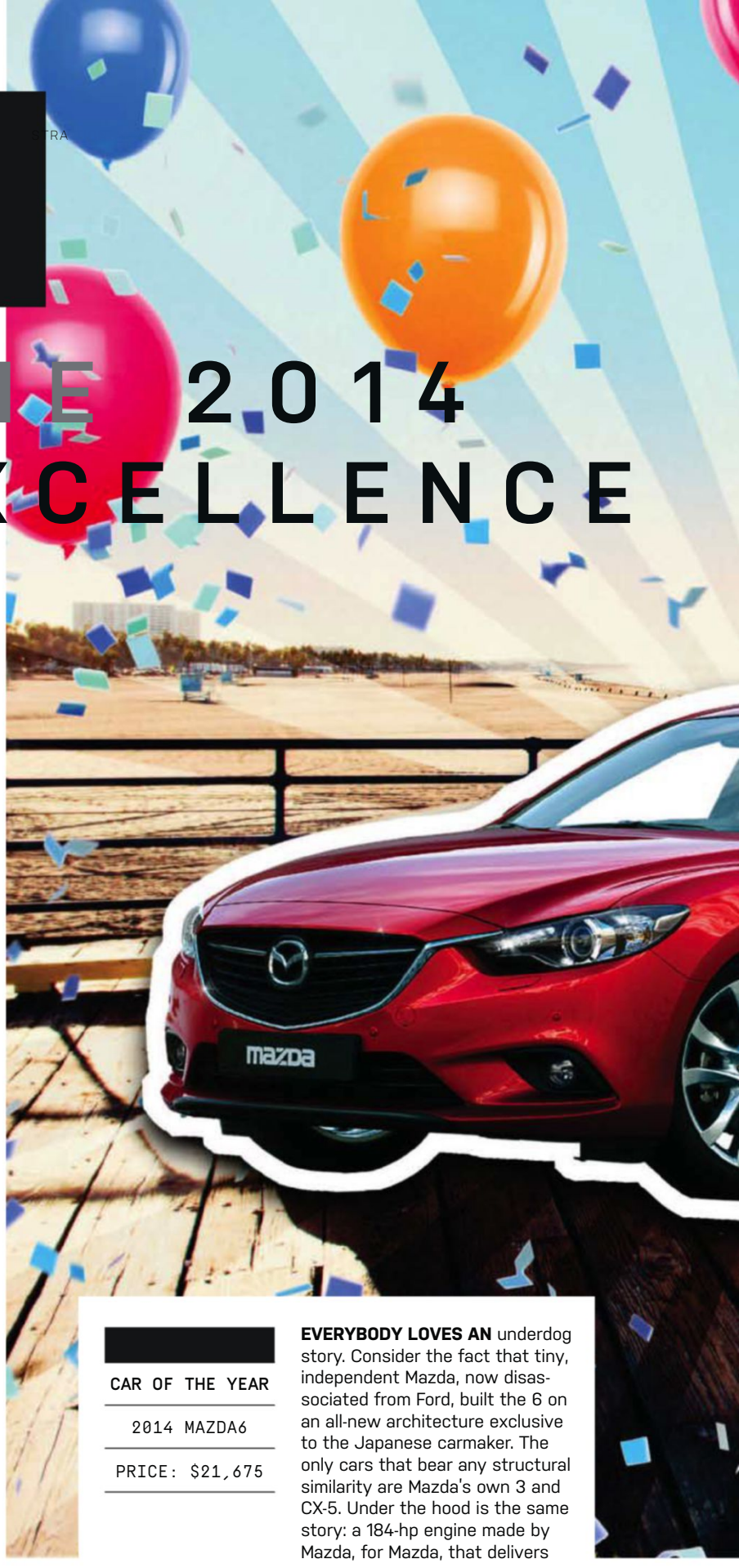
Edited by
ANDREW DEL-COLLE

THE 2014 EXCELLENCE

U.S. auto sales are booming. Just five years after the global financial crisis took more than one automaker to the brink of oblivion, nearly every company is selling cars as fast they can build them, on pace for the best year since 2007. The market is brimming with great cars—every segment is full of choices with modern styling and sporty driving dynamics. To top it off, diesels are coming back and cars are starting to drive themselves. It's been an exciting year for car enthusiasts, but it also makes deciding on just 10 winners harder than ever. As always, our picks range widely in price, size, and utility, but, collectively, they also represent the very best of an industry filled with new life.

— *THE PM AUTOMOTIVE EDITORS*

ILLUSTRATIONS BY **GLUEKIT**



[redacted]

CAR OF THE YEAR

2014 MAZDA6

PRICE: $21,675

EVERYBODY LOVES AN underdog story. Consider the fact that tiny, independent Mazda, now disassociated from Ford, built the 6 on an all-new architecture exclusive to the Japanese carmaker. The only cars that bear any structural similarity are Mazda's own 3 and CX-5. Under the hood is the same story: a 184-hp engine made by Mazda, for Mazda, that delivers

AUTOMOTIVE AWARDS



up to 40 miles per gallon on the highway. This, from a company about one-eighth the size of General Motors. And the Mazda6 drives like a sports car. No other family sedan is as responsive, yet the ride is still sufficiently supple. The cabin design is simple, but we appreciate the straightforward functionality. This is not to say the Mazda lacks comfort; there's plenty of space for two adults and a child seat in the rear. And just try to find an interior surface that's not padded. If you want the latest technology features, they're all available: adaptive cruise control, automatic high beams, lane-departure warning, blind-spot monitoring, and forward-collision warning. There's even an optional supercapacitor system that helps the alternator run less often, boosting mileage. Of course, it also helps that the Mazda6 is wrapped in sheet metal with curves that would make a Maserati jealous. But the 6 didn't earn our highest award because we're pulling for the little guy. It won because Mazda engineers set out to make a truly great car and succeeded.

POP MECH AUTO EXCELLENCE AWARDS 2014

PERFORMANCE

2014 CHEVROLET CORVETTE STINGRAY

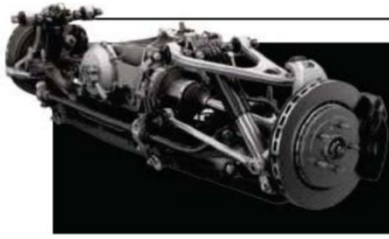
PRICE: $51,995



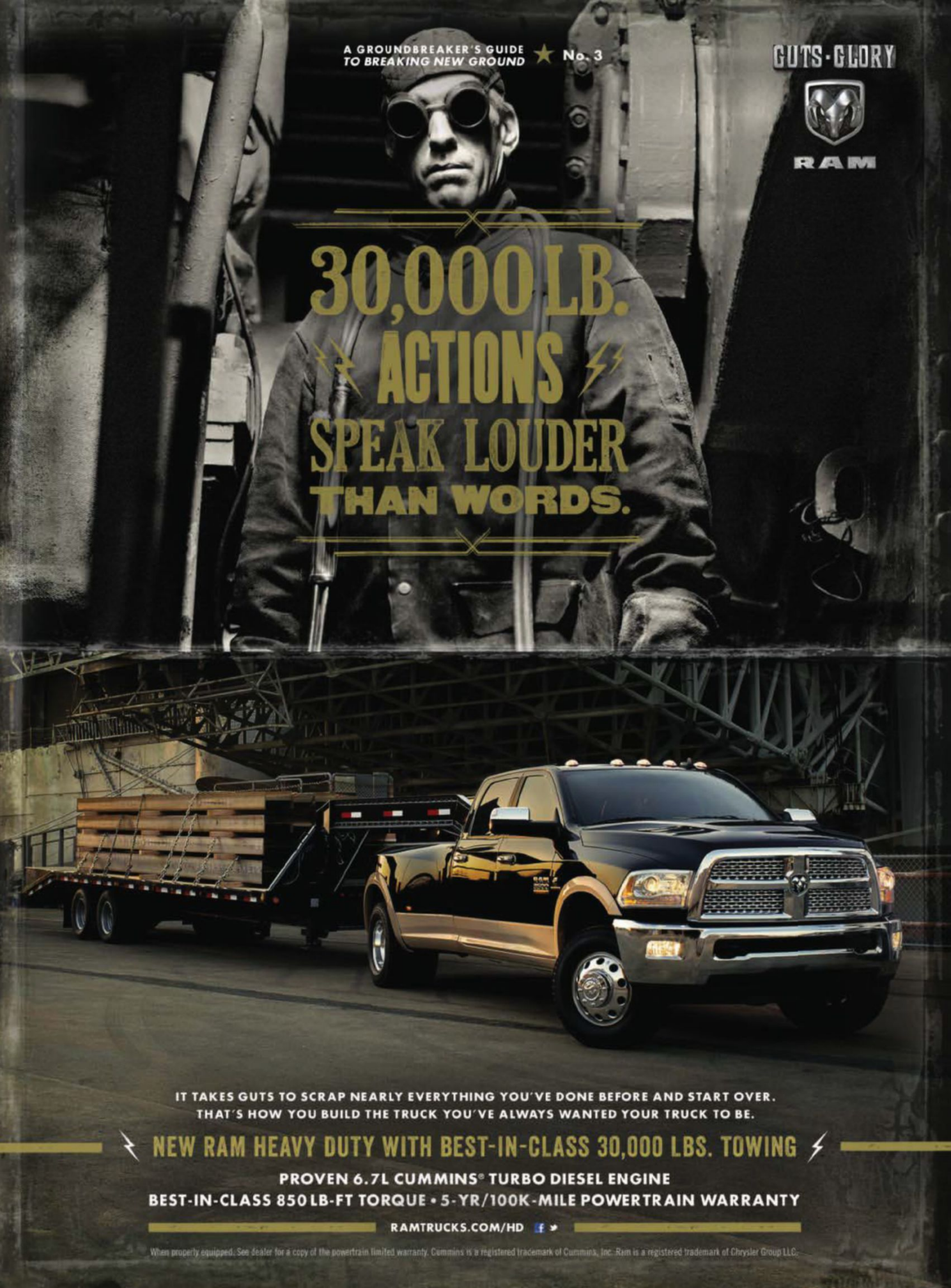
TRUTH BE TOLD, the Corvette Stingray could have won our award for value. It might sound funny, but this is basically a half-price supercar. Even with all the speed options the price is less than $61,000, and, thus equipped, the Stingray will hang corner for corner with the best sports cars in the world—and even manage to leave a few behind. But performance, of course, is a much more logical accolade for the new Vette.

Going fast dominates every aspect of the car's design. The interior, for example, has buttons for the important controls and GM's brightest digital-instrument-cluster display—both are features that facilitate speed. And all those scoops and vents on the outside are functional, letting the car breathe and reducing drag at the same time. But if looking at the Stingray made our jaws drop, driving it left us utterly speechless. It's not just the figures the Corvette can achieve in acceleration, braking, or lateral grip, it's the way this car feels fun at every mph. Zero to 60 in 3.8 seconds is certainly impressive, but making a car that's also responsive, predictable, and accessible to every driver, from novice to pro, is something special. This might be the world's best sports car.





CORNERING MADE EASY Much of our amazement with the Stingray comes from the optional electronic limited-slip rear differential. A computer-controlled clutch pack constantly adjusts the amount of locking between the rear wheels—open for better handling in tight spaces, closed for more stability in long, fast corners. It works so well that we're wondering if GM's engineers moonlight as magicians.


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VALUE

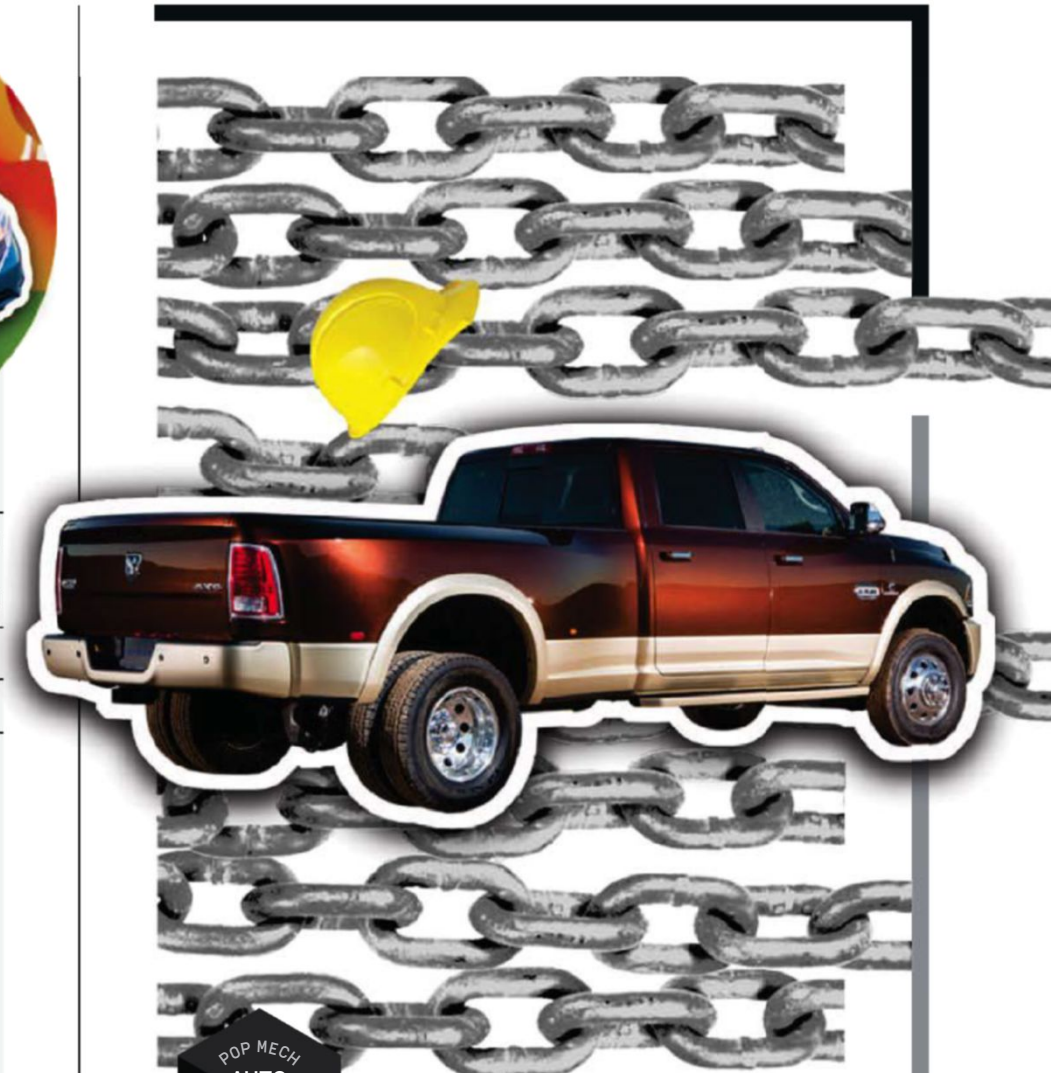
2014 NISSAN VERSA NOTE

PRICE: $14,780

THE LAST NISSAN Versa hatchback was certainly more homely than it was hip. No more. Now known as the Versa Note, this little five-door not only is the coolest of all the Versas but is also one of the slickest designs in the Nissan showroom—at any price. But unlike a hot-blooded GT-R or 370Z, the Versa's youthful sheet metal hides sensible utility. The exterior dimensions of the Note might suggest economy class, but inside it's strictly business. Slide into the rear seat and there's as much airspace between your knees and the front seatback as in a Chevrolet Impala. Go ahead, cross your legs and enjoy the road trip. And all this stylish, comfy living comes incredibly cheap. Okay, this is still an entry-level car. So you might want to splurge on a few options, such as the CVT instead of the five-speed manual transmission. This brings a significant 4-mpg boost to 40-mpg highway, which puts the Note at the top of the subcompact class in fuel economy. That means even more savings after you drive the Note off the dealership lot.

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POP MECH AUTO EXCELLENCE AWARDS 2014

HAULING

2014 RAM HEAVY DUTY

PRICE: $30,695–$44,240

MODERN HEAVY-DUTY pickup trucks can handle the most herculean tasks, but the tradeoff for this kind of extreme capability has always been a suspension so stiff the vehicle bucks and hops over a rough road like a bronco out of the gate. The 2014 Ram Heavy Duty breaks new ground in ¾-ton trim by ditching the old-time leaf springs in the rear for a sophisticated five-link coil-sprung suspension. This new Ram rides better than any heavy-duty before it, soaking up large bumps and chuckholes. But don't think the Ram HD has gone soft. There's an available 420-hp 6.4-liter V-8 that's new this year, as well as the option of dual alternators to handle the more extreme auxiliary electrical needs of a real workhorse. The 3500 series trucks still use the leaf packs in back, but each side also has an air spring to improve the ride. And when you pair the mighty Cummins turbodiesel with its 850 lb-ft of torque to this truck, it can lug a 30,000-pound trailer. Not only is that the most for any current pickup truck, it's also a figure that requires the driver to earn a commercial driver's license. Now that's serious.

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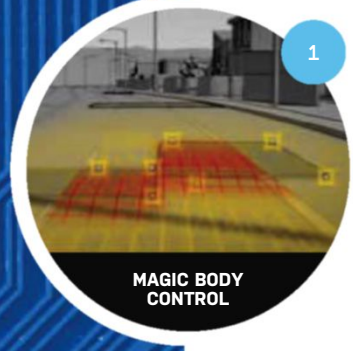
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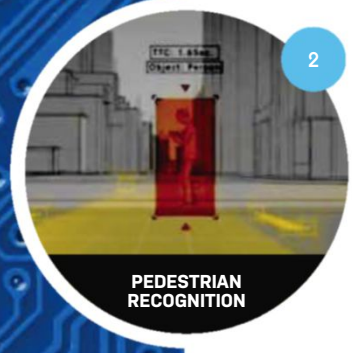
2014 MERCEDES-BENZ S-CLASS

PRICE: $93,825



WHERE TO BEGIN with the 2014 S-Class? Mercedes-Benz has more names for all its safety and driver-assistance systems than we have space to print, but just know that the S-Class's robust network of radars, cameras, and ultrasonic sensors makes it the most sophisticated—and arguably the safest—car on the road. (We're talking self-steering, self-braking, self-parking, the robots-are-coming-for-us kind of sophistication.) And new features such as the S-Class's Magic Body Control, which uses a stereo camera to read bumps in the road and preadjusts the suspension to absorb them, are another reminder that software is just as important as spring rate in a modern automobile. The 2014 S-Class is also the first car to forgo using a single bulb for any lighting, instead relying on 486 LEDs inside and out. Fifty-six of these can be found in each of the S-Class's headlights, which automatically adjust the beams' brightness and shape. The rest can be found in the rear lamps and hidden throughout the cabin, where, via a selector knob in the center console, the driver can control the giant 12.3-inch LCD center screen to change the color of the ambient lighting (we prefer Twilight Purple). Another IMAX-size LCD screen stretches behind the steering wheel to act as the instrument cluster and information hub. This is also where you'll see the night-vision display, which alerts the driver when the car detects pedestrians or animals. If all of this technology sounds excessive, it's not. In fact, it's the future. Mercedes just happens to be ahead of the curve.



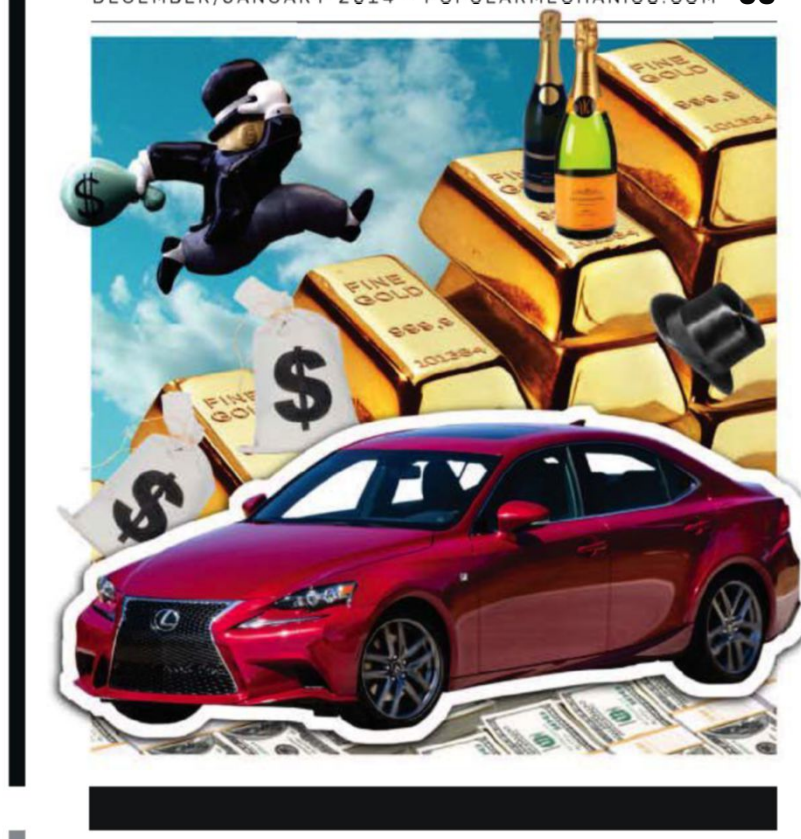




1 **HOW THE S-CLASS SEES IT** By using a stereo camera to scan the road surface, the S-Class can prep the suspension to almost completely eliminate body movements at speeds up to 81 mph.

2 Using a mixture of radars and its stereo camera, the S-Class can now detect vehicles and pedestrians and either aid in stopping if the driver does not brake hard enough or autonomously brake if the driver isn't paying attention.

3 At speeds up to 124 mph, the S-Class uses the stereo camera to read road lines and keep the car centered in the lane via the electrically assisted steering.



LUXURY

2014 LEXUS IS

PRICE: $36,860–$42,610

EVERY LEXUS PARKED on the showroom floor is stuffed with the comfort, craftsmanship, and refinement that have made the brand famous. The new IS overflows with these hallmark qualities, but what's new here is that Lexus has infused the chassis with the spirit of a hard-edged sport sedan. In a class once dominated by Germans, Lexus not only has matched these legends in performance—it has actually nosed ahead of them. The Lexus IS is tremendously talented. Opt for the F Sport package, available in the 204-hp IS 250 or the 306-hp IS 350, and the thrills on a snaky road multiply exponentially. And yet its BMW-conquering backroad competence is only one area where the IS shines. Lexus has managed to innovate on the inside too. On F Sport models, the carmaker uses a new method to inject foam into the faux-leather shell, making the supportive high-performance seats remarkably soft. Perhaps best of all, the IS starts below $37,000. So the most accomplished sedan in the class is also a great deal.

POP MECH AUTO EXCELLENCE AWARDS 2014

DESIGN

2014 JAGUAR F-TYPE

PRICE: $69,895–$92,895

THE LIGHT SIDE One of the F-Type's cooler design elements is the shape of the headlights, which was inspired by the *Star Wars* TIE Interceptor spacecraft.



THE JAGUAR F-TYPE demands attention. Slinking through the streets of Monterey, Calif., the week before the Pebble Beach Concours d'Elegance, we watched as neck after neck snapped to admire our rakish V8 S. The F-Type's epic exhaust note was surely partially to blame, but even when we parked, people swarmed the car to ask questions and sneak peeks at the roadster's equally handsome interior. And when we pulled up to The Quail, a swanky car show, the parking attendant promptly directed us to a prominent grassy knoll along the main road. Our company? Three Ferraris. So, yeah, people like the F-Type. And it's easy to see why, with its aggressive stance and a front end that looks built to devour pavement. But for Jaguar director of design Ian Callum, the F-Type presented a daunting task: create the British company's first roadster since the venerable E-Type. No slave to history, Callum successfully paid homage to Jag's past while advancing its current styling. The rear, Callum's favorite part of the car, is especially arresting, with its huge haunches and distinctive wraparound taillights. What we love most about the F-Type, though, is how all its elements come together. Great design is cohesive, and there's nary a contrary line on this car. That's why people gawk, that's why they crowd around, and that's why you get to park on the hill.

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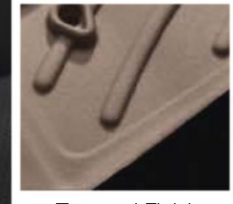


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THE JEEP BRAND defines versatility. And the Cherokee has always blended off-road capability, on-road performance, and family utility better than any other Jeep. It's fitting, then, that the reborn Cherokee is perhaps the most diversely equipped to carry the legendary name. At one end of the spectrum there's a front-drive four-cylinder model that delivers carlike handling, 31 mpg on the highway thanks to its nine-speed automatic, and room to pack nearly 55 cubic feet of gear behind the front seats. Best of all, the front passenger seat folds flat, so that 6-foot bookcase from the furniture store can fit inside. At the dirtier end of the option sheet is the mighty Trailhawk model, which has the bones of a real off-roader. Because the Cherokee is based on a front-drive crossover platform, the two-speed 4WD system uses an innovative gear-reduction system at each axle, instead of a traditional central transfer case. And to provide truly outstanding off-road performance, there's an electronically locking rear differential that gives the Trailhawk the talent to master the Rubicon. Back on the pavement, if there's a trailer that needs to be moved, the V-6 Cherokee with its 271 hp and 239 lb-ft of torque can handle 4500 pounds of weekend toy. The new Cherokee's functionality carries over to its interior, where the cargo hold features a smart hook-and-rack system to handle Jeep-brand accessories such as a soft-sided cooler or a collapsible dog cage. There's even a tray for your grocery bags. The new Cherokee is clever, fuel-efficient, and incredibly versatile. In other words, it's a true Jeep.

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POP MECH AUTO EXCELLENCE AWARDS 2014

HANDLING

2014 FORD FIESTA ST

BASE PRICE: $22,195

THE FORD FIESTA ST follows a classic recipe for fun-to-drive: Take an existing small car, then add a hotter engine and a sportier suspension. Ford's own Focus ST is a great example, as is the segment-defining Volkswagen GTI. But those cars and others like them have slowly inflated in both dimension and price. The Fiesta ST takes the compact performance back to its roots—an affordable small car that's just fast enough to keep life interesting. Like the great hot hatches before it, the Fiesta never fails to put a smile on our face. The fun starts with the fat, leather-wrapped steering wheel that makes the car respond so quickly it's almost twitchy. But the ST's handling is smooth, and it's easy to transition from braking, to cornering, and then on to the gas to feel the surge of the 197-hp 1.6-liter EcoBoost engine. From the Fiesta ST's bolstered driver's seat, every road looks like a racetrack, even if it's just an open on-ramp.

EFFICIENCY

2014 CHEVROLET CRUZE DIESEL

PRICE: $25,695

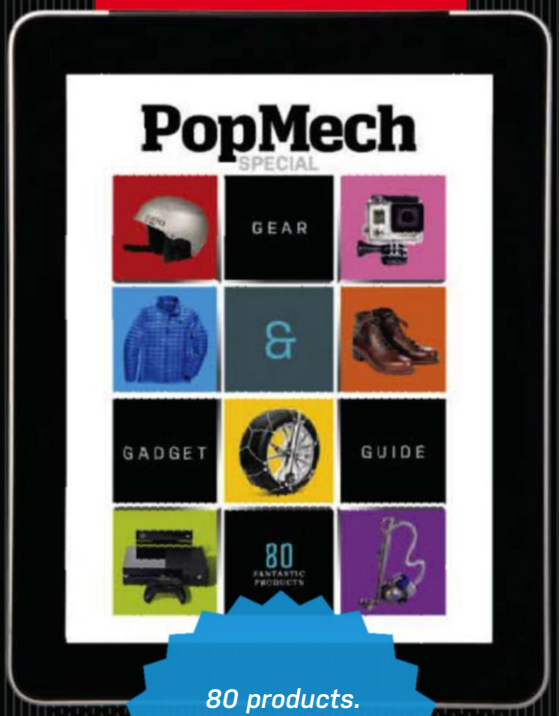
GENERAL MOTORS' FIRST new diesel car in more than two decades, the Cruze is the most efficient nonhybrid on the market (27 city/46 highway) and the only diesel sedan offered stateside by the Big Three. That's a big deal. To meet U.S. emissions standards, GM modified its European turbocharged 2.0-liter diesel I-4 mill, which produces 151 hp and a stout 280 lb-ft of torque. And to mute any excessive engine noise, the General reappropriated the Buick Verano's sound-deadening setup. The Cruze diesel does cost $2390 more than an equivalently equipped gas Cruze, but as with an EV or hybrid, you'll eventually make up the cost difference. Chevy also sweetens the pot with a free two-year service plan for diesel-fluid replacement, oil changes, and tire rotations. All together, this makes the diesel not only the best model in the Cruze lineup—but the best diesel deal this side of the Atlantic.

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Often it's simply an unmet need. One that Cub Cadet answered with the **RZT™ S ZERO,** an electric zero-turn riding mower that Popular Mechanics named among an elite assembly of its 2013 Breakthrough Award winners.

"The ZERO is truly the first of its kind. Never before has the world seen a zero-turn riding mower with steering wheel control and four-wheel steering that's fully electric," said Jeff Salamon, Cub Cadet's director of marketing. "But it's what you don't get that's truly remarkable... zero engine noise, zero gasoline, zero oil, belts and filters, zero emissions, zero worries, and zero compromise in performance."

The ZERO is innovation at its best. It's the future of lawn care. And it's just one of many Cub Cadet products that will change the way you care for your yard.

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INNOVATION ECONOMY • BY CHRIS ANDERSON

From Maker Movement to New Industrial Revolution

TOOLS LIKE 3D PRINTERS CAN TURN HOBBYISTS INTO MANUFACTURERS.

Four years ago, when I was a magazine editor, I bought one of the first consumer 3D printer kits. It was one of the early MakerBot Cupcakes and it barely worked, but it blew my mind. It also changed my life. Today I've moved from media to manufacturing: I run 3D Robotics, a drone company with a big electronics and assembly factory in Tijuana, Mexico. (Yes, a Tijuana drone factory. Beat that, sci-fi!)

How is it possible for a magazine editor to become a high-tech manufacturer, essentially overnight? And how do you go from a bag-of-parts 3D printer to a full-scale factory? The answers are rooted in a revolution that's come to manufacturing over the past five years. The changes boil down to three ideas: desktop, digital, and cloud.

DESKTOP FABRICATION

First: desktop. In the 1980s the personal computer brought desktop publishing to anyone who was interested, making a process that used to require typesetters and printing presses available to all (and creating a class of content creators who would ultimately fill the Web).

Now desktop fabrication tools are doing the same for physical objects. The 3D printer was the first of those technologies to go mainstream, but today in my home workshop my kids and I also use desktop CNC mills (a subtractive process that cuts away material, unlike a 3D printer's additive process of laying down new material), 3D scanners, CAD software, and even a desktop injection-molding machine. These machines cost less than $2000 each, and they are getting nearly as easy to use as an inkjet printer. A lot of the necessary CAD software is free.

True, none of these are designed for mass production; they're small and somewhat limited in the materials they can use. But you'd be surprised at how much of the manufacturing process can be done at this scale.

Take the injection molding of plastic parts. This is traditionally an expensive and time-consuming process for any company making hardware. After a part has been designed in CAD and prototyped on a 3D printer, it's typically sent to specialists to be turned into a mold, and then to an injection-molding factory that makes the final parts. That's a process that can cost at least $10,000 and take more than two months—just to get ready to start actually manufacturing anything.

For complex parts and large runs, that's still the right way to do it. But for simple components that will be made in batches of up to a few thousand, the whole process can now be done with desktop tools. Once you have the part itself designed, you can use plug-ins for CAD tools to generate a design for your mold, and then carve it out of aluminum on a three-axis desktop CNC mill. That mold can then be used with a desktop hand-pressed injection-molding machine that's no larger than a small drill press.

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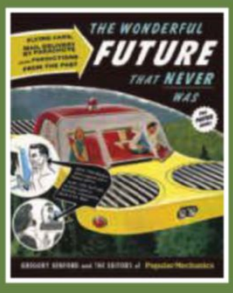
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an hour. Several thousand can be produced in a few days by someone with no special skills at a cost of a few hundred dollars, as little as 1 to 2 percent of what professional production would cost. More important, the timeline is days, not months—you can make the parts on demand. The time savings alone can make this a game changer for small, fast-moving companies.

These are all examples of desktop manufacturing, which is the enabling technology trend for the maker movement. Although the manufacturing capability is sometimes exaggerated (desktop prototyping is usually closer to the truth with 3D printers), what's important about this democratization trend is that it taps the huge pool of talent, energy, and creativity outside the world of trained professionals.

Just like the PCs of the 1980s (which were more feeble than the professional computers of the time but available to far more people) and the Internet of the 1990s (which was slow and limited at the start but open to all), what desktop manufacturing tools lack in power, they more than make up for in accessibility. And they're getting better and cheaper even faster than the computing and communications technologies of the past two generations did—in part because they are built on the PC and the Web, and have inherited innovation models such as online content sharing that those technologies created.

THE POWER OF CODE

That brings us to the power of the second idea in the new industrial revolution: digital. Because these desktop tools have computers at their core, smart software replaces the machine-shop skills that used to be required to use them. Just as with desktop publishing a generation ago, complexity is replaced by code. Increasingly, what had been guild-like knowledge is being presented through onscreen wizards—and amateurs can handle processes that used to require trained toolmakers.

That dramatically lowers the barrier to entry for turning ideas into prototypes. And because today's designs start onscreen, in CAD tools of one sort or another, they exist as digital files that can easily be shared and modified. And that means that they align with the weave of the Web, fitting naturally into the online sharing and collaboration culture and turning what would have once been solo efforts into community projects.



PHOTOGRAPH BY JOE PUGLIESE

Chris Anderson, the former editor-in-chief of *Wired* magazine, is the cofounder of 3D Robotics, which sells small UAVs. Like many new entrepreneurs, he benefited from easy-to-use desktop tools such as 3D printers.

CLOUD-BASED SERVICES

That brings us to the third concept: cloud. Those same digital files don't have to be turned into physical objects on a desktop—they can also be sent to factories to be manufactured at any scale. A wide range of online manufacturing services has emerged alongside the maker movement, including Shapeways for 3D printing, Ponoko for laser cutting, Protomold for injection molding, and MFG for machine-shop services. (There are dozens of others for electronics at sites such as Alibaba, a gateway to working with Chinese factories of all sorts.)

That means that we finally have an end-to-end fabrication chain that's open to the individual, from prototyping to mass production. What the Web did to open media to the masses, the new movement is doing for manufacturing.

How am I so sure of all this? Because that's exactly the path we took at my own company. My cofounder, Jordi Munoz, and I started with an online community designing electronics and sharing files back and forth. Then Jordi bought a used desktop pick-and-place machine from eBay to make the electronics. After that came the CNC mills to make the drone airframe parts, bigger and better pick-and-place machines, 3D printers for prototyping, and more. For hard things, we started with cloud services such as Protomold and Alibaba, and then, once we understood them better, we brought that production in-house to save money and time.

Three years ago the company consisted of Jordi hand-soldering on a folding card table in his garage and me and my kids packing kits on the dining room table. Now we've got 35,000 square feet of factory space with four high-end pick-and-place lines, three CNC lines, and factory managers hired from companies such as Samsung and Foxconn running the show. All of this was learned by doing, not by schooling. And that's the magic of the new industrial revolution. **PopMech**

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ILLUSTRATION BY **SACHIN TENG**

THINKING AHEAD • BY GLENN HARLAN REYNOLDS



Mosaic Theory

HOW LICENSE-PLATE SCANNERS ERODE PRIVACY.

HERE'S A THOUGHT EXPERIMENT: IMAGINE that activists, concerned with official misconduct, install license-plate readers on private property to track the location of every car belonging to the police department or a politician and upload the locations to a public database. The result: a map of where the police go, and where they don't—along, perhaps, with politicians' visits to motels or strip clubs.

Given that police often respond with hostility to simply being videotaped, I expect that a venture like this would prompt an outcry, and probably some efforts to shut it down. But this is precisely what officialdom is doing to citizens.

We now know that federal, state, and local law enforcement agencies are using automated license-plate scanners, mounted on everything from telephone poles to police cars, to build a huge database of where people are driving. This might seem like a small intrusion compared with the electronic spying carried out by the NSA. But not all threats to privacy involve the tracking of emails and other communications.

Right now, the law suggests that license-plate scanners don't invade your privacy because they record only events that occur in public. After all, anyone could see you driving down the road or parked in front of a motel. But if officials add up enough bits of information like that, they gradually can construct what the ACLU has termed a "single, high-resolution image of our lives."

There's a legal term for this idea: the mosaic theory. *The New York Times* ran a story last year about how a man angrily confronted a Target store manager to complain that the company was sending his teenage daughter coupons for baby goods. Were they trying to encourage her to get pregnant? Nope. Target's data-mining operation had found a strong correlation between purchases of about 25 items—scent-free lotions, certain nutritional supplements, and so on—and different stages of pregnancy. The teenager's purchases had fit the pattern. The father apologized to Target a few days later, when it turned out that his daughter was, in fact, pregnant.

Law enforcement agencies may not know or care what toiletries you buy, but they can access credit reports and property tax records, which are public information. Setting that aside, simply tracking our movements can erode our privacy. The Supreme Court recently held that police need a search warrant to attach a GPS tracker to an individual's car, even though the device would just be recording travel along public roads. The decision turned largely on the idea that placing a locating device on your car is a trespass on your property. But five justices also suggested some sympathy to the mosaic theory as a legal argument; whether the court actually adopts such an approach will have to wait for a later case.

The Supreme Court, though, isn't the first step in protecting privacy; it's the last. If people are unhappy with the notion of having their movements, email, Web searches, and other behavior tracked, there's nothing to stop Congress, or state legislatures, from limiting this sort of activity, both on the part of private businesses and, more significantly, on the part of law enforcement. When it comes to protecting your rights and privacy, there's no reason to wait for courts to act.

And while we're at it, maybe we should enable the public to return the surveillance favor. In his prophetic 1998 book, *The Transparent Society,* David Brin wrote that technology was going to make it almost impossible to stop snooping. But, he suggested, if the government and corporations want to spy on us, they should let the public know what they are doing, too, by letting us track *their* data. We can set up Web feeds from every police headquarters, for a start. Today, we're living in Brin's world, or at least we're halfway there. Big organizations are already watching individuals—perhaps it's time to open things up in the other direction. **PopMech**

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the NEW Space AGE

RIGHT NOW AMERICAN ENGINEERS ARE DESIGNING AND TESTING MORE NEW MANNED SPACECRAFT THAN AT ANY OTHER TIME IN HISTORY. HERE ARE SEVEN VEHICLES THAT WILL CHANGE HOW WE WORK AND PLAY IN SPACE.

by jeff wise

WHEN THE SPACE SHUTTLE TOUCHED DOWN FOR THE LAST TIME, in 2011, America no longer had the hardware to launch a human into orbit. Now, driven by private industry, the country is again becoming a spacefaring nation. "We're in a transitional phase," says Marco Caceres, director of space studies at the Teal Group, an aerospace consulting firm. "Private companies are leading in space, and that means things are going to get cheaper. That gives you more latitude to dream." NASA itself is focusing on deep-space missions, including a manned trip to an asteroid. Some of these projects may stall due to failures of funding or engineering; if only a handful fly, it means a new golden age of U.S. spaceflight has arrived.

ILLUSTRATION BY **JEREMY COOK**

RUNWAYS ARE FOR ROCKETS

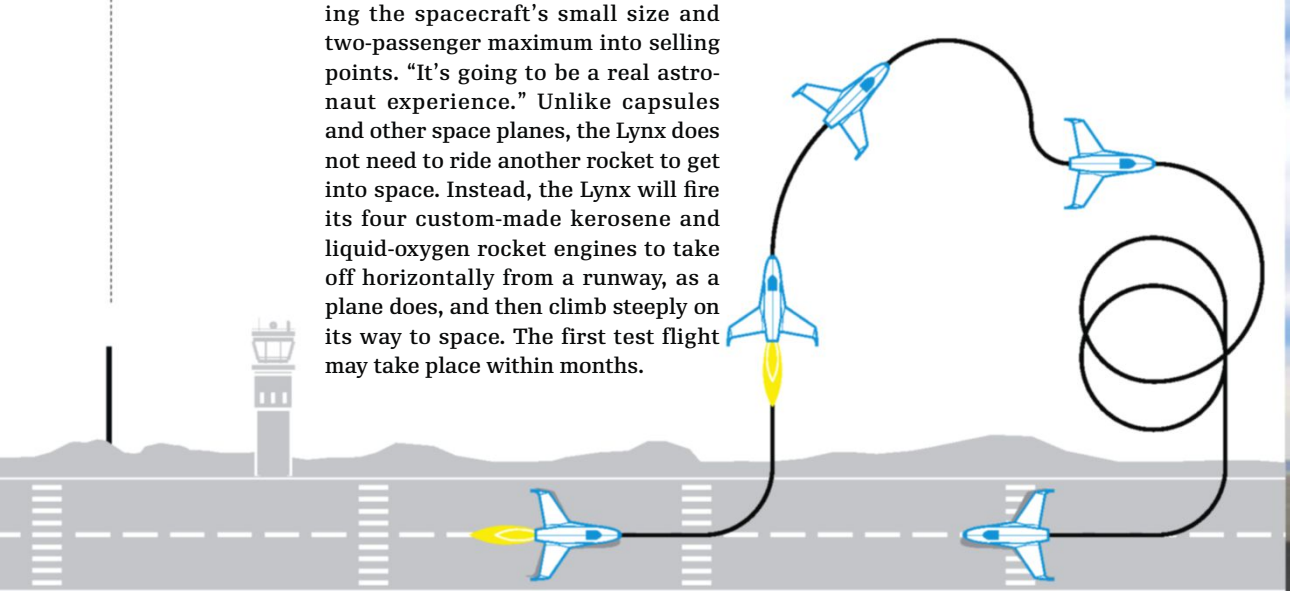
Craft: Lynx (pictured on previous page)

Type: Self-launched space plane **Who:** XCOR Aerospace **Launching:** 2014
Destination: Suborbital **The Odds:** Good

SPACE IS DEFINED BY A somewhat arbitrary number—climb above an altitude of 62 miles, the so-called Kármán Line, and an aircraft becomes a spacecraft. There the atmosphere is so thin that, for most scientific purposes, it's a vacuum. Because a so-called suborbital space flight to this altitude requires much less energy than an orbital launch—about one twenty-fifth as much—many private space companies are devising ways to get science experiments and wealthy tourists there. XCOR Aerospace of Mojave, Calif., believes it can offer the cheapest trip. It is already selling $95,000 tickets on a 30-foot space plane called the Lynx. "You're sitting in the cockpit," says XCOR chief operating officer Andrew Nelson, turning the spacecraft's small size and two-passenger maximum into selling points. "It's going to be a real astronaut experience." Unlike capsules and other space planes, the Lynx does not need to ride another rocket to get into space. Instead, the Lynx will fire its four custom-made kerosene and liquid-oxygen rocket engines to take off horizontally from a runway, as a plane does, and then climb steeply on its way to space. The first test flight may take place within months.

HOW IT WORKS

Takeoff: The space plane speeds along a runway under the power of four rocket engines.
Ascent: The Lynx reaches Mach 2.9 as it speeds straight upward.
Apogee: The engines cut out about 3 minutes after takeoff. The craft follows a parabolic trajectory in suborbital space.
Reentry: Thermal insulation on the nose and leading edges of the wings protect the craft from the heat of reentry.
Landing: The space plane sheds speed by circling in a downward corkscrew. The wing area is sized for landing at moderate speeds, near 110 knots—a little slower than that of an airliner during a landing.
Fly again: Lynx's creators say the space plane will be able to make four flights a day.



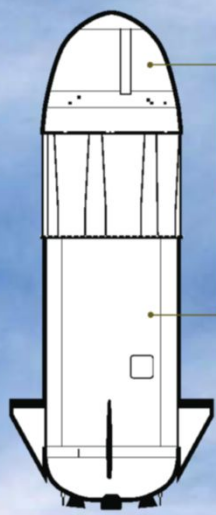
ILLUSTRATIONS BY **MARTIN LAKSMAN**

Secret Spacecraft

Craft: New Shepard

Type: Manned capsule **Who:** Blue Origin/Jeff Bezos **Launching:** Unknown **Destination:** Suborbital **The Odds:** Good

VISIONARY BILLIONAIRE JEFF BEZOS, THE 49-year-old founder of Amazon.com, has spent more than a decade on a secret project to conquer space. Bezos poured millions of his $25 billion fortune into a venture called Blue Origin, operating out of an experimental launch site he created (with FAA approval) in a remote corner of West Texas. In 2011 the company released footage of a lozenge-shaped preliminary test vehicle, New Shepard, taking off vertically, hovering at an altitude of 548 feet, and then setting gently down. A booster with the ability to land under its own rocket power after separating from a capsule would trim the high cost of retrieving it from the ocean after a splashdown.



A TWO-PART VEHICLE

The **propulsion module** propels the entire spacecraft off the launchpad. The pressurized **crew capsule** detaches and heads into space. The propulsion module's main engine powers a vertical landing near the launch site. The capsule returns to Earth under a parachute.



Internet entrepreneur Jeff Bezos (above) kept the existence of his spaceflight company a secret for three years after he founded it in 2000. The company flies experimental vehicles, such as this flight-test capsule, at its private West Texas spaceport.

PHOTOGRAPH BY BLUE ORIGIN

Tourism Trailblazer

Craft: SpaceShipTwo

Type: Air-launched space plane **Who:** Virgin Galactic/Richard Branson
Launching: 2014 **Destination:** Suborbital **The Odds:** Very good





The first SpaceShipTwo craft, shown here in a glide test, will be followed by four others carrying tourists for Virgin Galactic.

DURING THE GOLDEN AGE OF AVIATION BETWEEN WORLD Wars I and II, radical airplane design was inspired by high-dollar challenges. In 1927 Charles Lindbergh crossed the Atlantic to win the $25,000 Orteig Prize. The modern equivalent, the Ansari X Prize, helped create what will likely become the first operating space tourism venture, Virgin Galactic. In 2004 a single-seat craft called SpaceShipOne launched from an airplane, breached the Kármán Line, repeated the feat within two weeks, and won the $10 million prize. The hardware, built by famed designer Burt Rutan in collaboration with Virgin Group mogul Richard Branson (above, left), laid the groundwork for a business to take customers along for the ride. The new version will carry up to six tourists and two pilots on a two-part journey to space. First the 60-foot-long, 140-foot-wingspan craft's mothership, WhiteKnightTwo, will haul SpaceShipTwo to an altitude of 50,000 feet. Then the rocket ship will detach, fire its engine, and zoom spaceward. At an altitude of 68 miles, the curvature of the Earth and the serene glow of the atmosphere will be visible against the blackness of the cosmos. The $250,000 ticket will grant riders only about 4 minutes of weightlessness. More than 600 customers, including Justin Bieber, Ashton Kutcher, and Leonardo DiCaprio, have signed up for the trip. "I believe over the next few decades, we will take hundreds of thousands of people to space," Branson tells PM via email. "My vision for Virgin Galactic is to make affordable manned access to space a reality."

Spaceports on the Rise



Here are updates from some of America's prominent spaceports.

- **Mid-Atlantic Regional Spaceport:** This state-run operation is based at the NASA launch facility on Wallops Island, Va. In September Orbital Sciences Corp. launched its Cygnus capsule to the International Space Station, establishing the spaceport as a center of private space operations.
- **Spaceport America:** In New Mexico a 12,000-foot runway is open, and freshly recruited runway fire crews arrived this year at the first facility built solely to support private space operations. The New Mexico site is the headquarters for Virgin Galactic, which hopes to begin ferrying space tourists next year.
- **Kennedy Space Center:** This famed NASA spaceport in Florida is now hosting private companies. SpaceX and Blue Origin are clashing over a launchpad that was once used by NASA's most powerful rockets. NASA is keeping a nearby launchpad ready for its proposed heavy lifter, the Space Launch System.

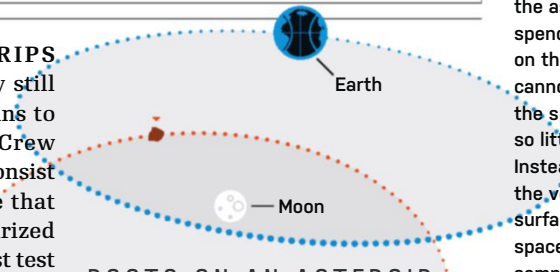
PHOTOGRAPH BY MARK GREENBERG

CONGRESSIONAL CAPSULE

Craft: Orion

Type: Interstellar manned stretch capsule **Who:** NASA/U.S. Congress
Launching: 2021–2025 **Destination:** Asteroid, Mars **The Odds:** Even

NASA IS OUTSOURCING TRIPS to Earth's orbit, but the agency still has eyes on deep space and plans to use the Orion Multi-Purpose Crew Vehicle to get there. Orion will consist of a capsule mated to a module that provides propulsion and pressurized living quarters. The capsule's first test flight will take place in 2014: It will be carried into space on a 235-foot Delta IV rocket, reenter the atmosphere, and splash down in the Pacific. Orion may get a new ride for its actual missions. Work is under way at NASA facilities in Huntsville, Ala., on the Space Launch System, a 321-foot-tall rocket. Such a heavy lifter will come in handy when (or if) NASA astronauts head to the moon, an asteroid, or beyond. "More and more," says Dan Dumbacher, director of NASA's Exploration Systems Development office, "we're talking about Mars as our ultimate goal." The vision may be too ambitious, critics say. The launch system is so huge that NASA envisages using it only every two years, at $6 billion a pop.



BOOTS ON AN ASTEROID

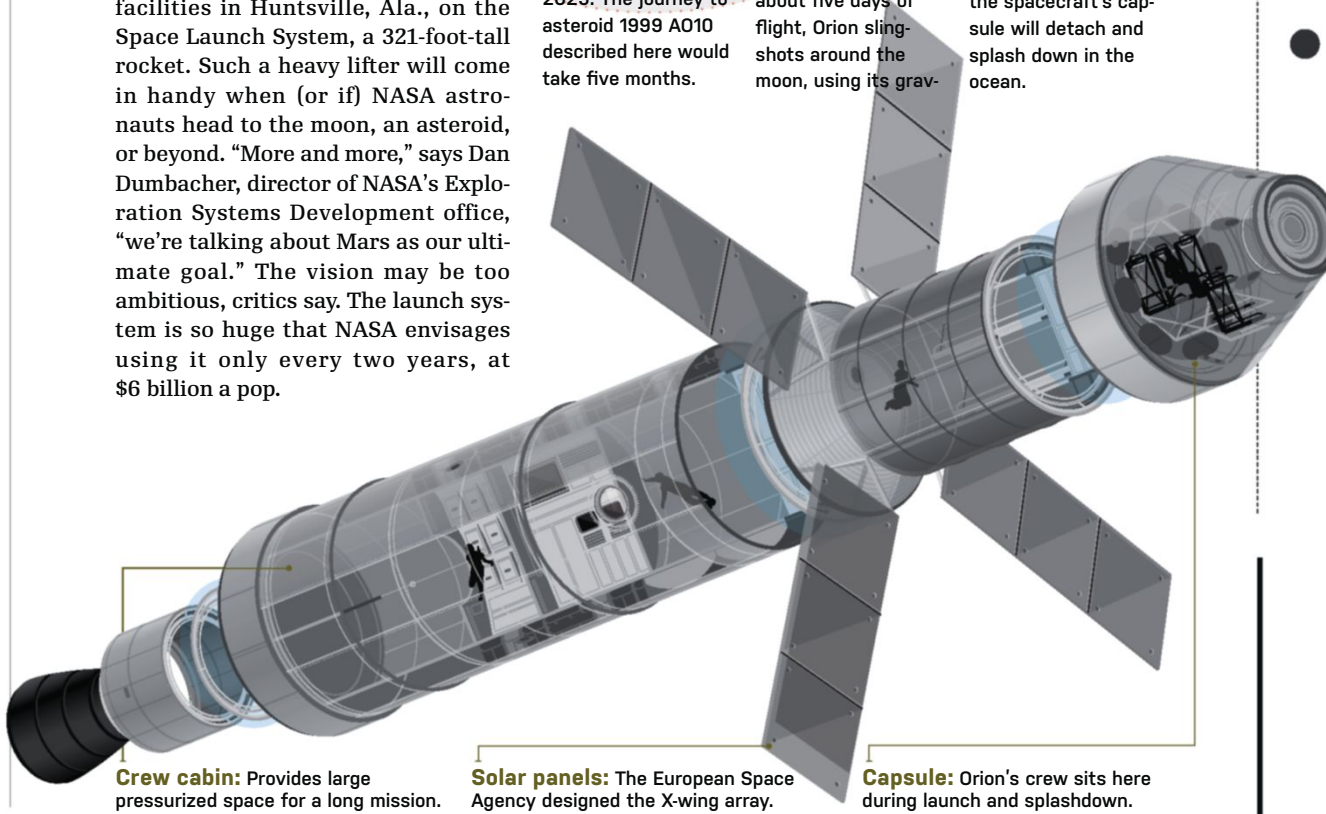
NASA is considering sending astronauts in an Orion spacecraft to the surface of a near-Earth asteroid in 2025. The journey to asteroid 1999 AO10 described here would take five months.

The Launch: The Orion, with a crew of four, launches from Cape Canaveral, Fla.

The Flyby: After about five days of flight, Orion slingshots around the moon, using its gravity to catch 1999 AO10.

The Rendezvous: Two months after liftoff, the crew reaches the asteroid. They spend two weeks on the surface but cannot land because the space rock has so little gravity. Instead, they secure the vessel to the surface and conduct space walks to take samples.

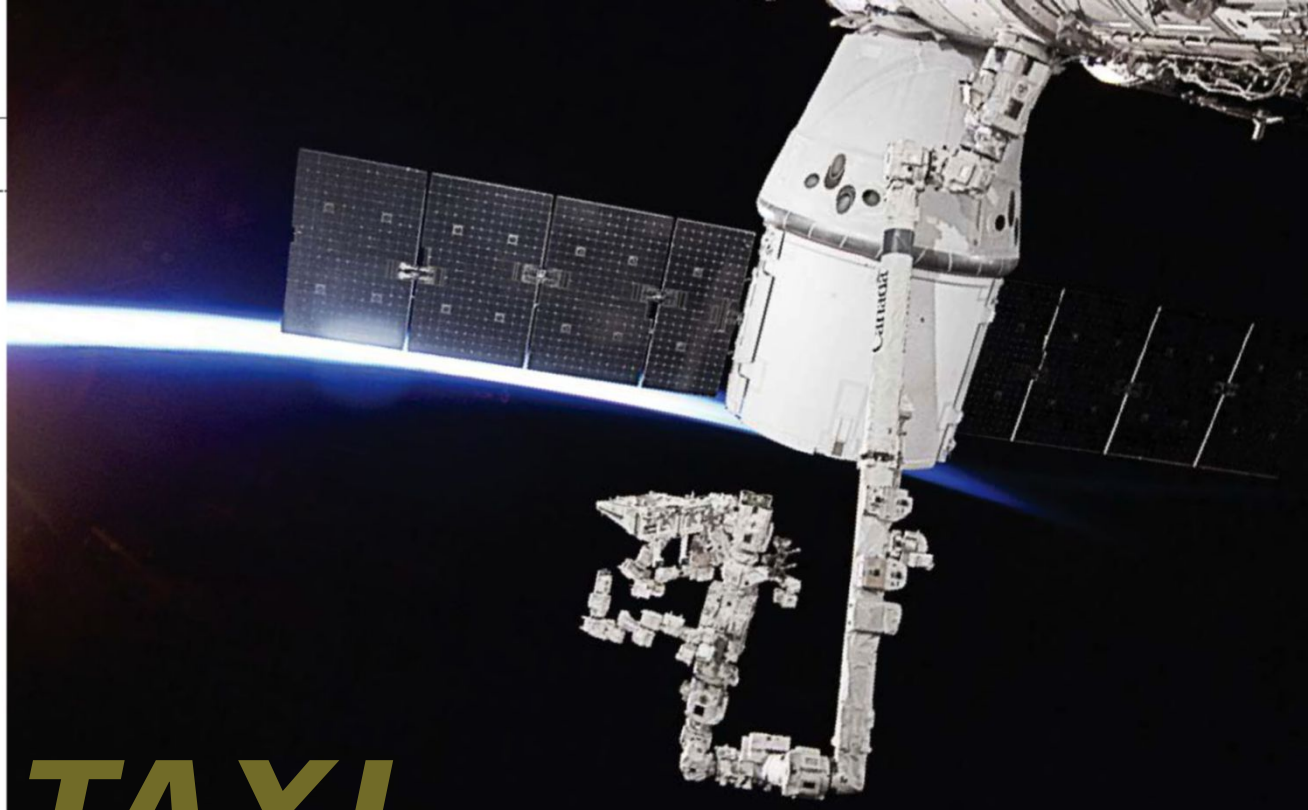
The Return: Since 1999 AO10 is approaching Earth, the trip home will be slightly shorter. Once in Earth's orbit, the spacecraft's capsule will detach and splash down in the ocean.



Crew cabin: Provides large pressurized space for a long mission.

Solar panels: The European Space Agency designed the X-wing array.

Capsule: Orion's crew sits here during launch and splashdown.



TAXI

TO THE SPACE STATION

Craft: Dragon

Type: Manned capsule **Who:** Space Exploration Technologies/Elon Musk **Launching:** 2015
Destination: Orbit (International Space Station) **The Odds:** Very Good

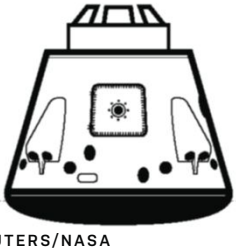
SKEPTICS HEAPED DOUBT ON Elon Musk (below, right) in 2002 when he founded Space Exploration Technologies, or SpaceX. But by 2010 his scrappy startup became the first to replicate what only government had achieved when an unmanned Dragon capsule rode a Falcon 9 rocket into orbit, then descended via parachute, and was recovered from the Pacific. The next step on Musk's conquest of space: upgrading the reusable Dragon into a human-rated craft called DragonRider that can carry crew to the ISS. Using innovative design and operations, SpaceX says human flight will cost only $20 million per seat; the U.S. currently pays about $63 million per passenger on the Russian Soyuz. It takes an iconoclastic billionaire to form a spaceflight company. "The demand for human space transportation is uncertain and the penalties for failure are immense," says Scott Pace, director of George Washington University's Space Policy Institute.

A Dragon capsule (above) attached to the International Space Station in 2012. The station's arm stands by to grip the capsule when it detaches for a return trip to Earth.



DRAGON TO DRAGONRIDER

Engineers are transforming the unmanned Dragon capsule into the DragonRider spacecraft.



Larger windows: Astronauts will monitor from windows as they dock to the space station. Riders of future versions landing with rockets need more visibility.

More thrusters: In an emergency 18 SuperDraco thrusters on the capsule's sides could carry a crew into orbit with 120,000 pounds of axial thrust.

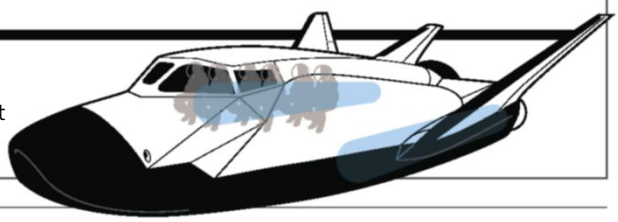
Improved interior: The capsule will be outfitted for a crew of seven. Since the unmanned version is pressurized, the capsule is easy to reconfigure for humans.

PHOTOGRAPH BY **REUTERS/NASA**

Son of Shuttle

Craft: Dream Chaser

Type: Rocket-launched space plane
Who: Sierra Nevada Space Systems
Launching: 2017 **Destination:** Earth orbit
The Odds: Good



SPACE PLANES HAVE ADVANTAGES. INSTEAD OF PASSIVELY plummeting through the atmosphere like a capsule, they can maneuver, change their landing destination midflight, and be reused after a short turnaround. But two U.S. space shuttle disasters suggest that space planes are not ideal for orbital missions. By carrying cargo and crew in the same vehicle, the shuttle required that everything be carried aloft on expensive, human-rated equipment. Also, tacking the shuttle alongside its boosters and fuel tank allowed for the kind of debris strike that doomed *Columbia*. But Sierra Nevada Space Systems is betting it can redeem the reputation of the orbital space plane with the Dream Chaser, a winged crew-delivery vehicle that's competing for NASA contracts to deliver people to the ISS. Dream Chaser will avoid the shuttle's main flaws by carrying crew separately from cargo and by launching atop an Atlas V rocket. But it will retain its advantages, including a maximum deceleration on reentry of only 2 g's—1 g less than what a capsule experiences. The spacecraft also has flexibility as to where it can land. "Anywhere a 737 can land, Dream Chaser can too," says Mark Sirangelo, vice president of Sierra Nevada. Suborbital test flights are slated for 2015, with launches to orbit two years later.

RIDE INSIDE

Up to seven passengers can ride Dream Chaser into space. The spacecraft hitches into orbit on the tip of a rocket, detaches, and is designed to back in to the docking station of the space station. Dream Chaser has not yet flown, but engineers towed the craft for runway evaluations (below) and dropped it from helicopters for glide tests.



PHOTOGRAPH BY NASA

ILLUSTRATION BY **NATHAN FARISS**



Inspiration Mars

An Extraterrestrial Honeymoon Suite

Type: Interplanetary transport **Who:** Inspiration Mars Foundation/Dennis Tito **Launching:** 2018
Destination: Mars **The Odds:** Long

THE RED-BROWN MARTIAN landscape slowly rolls beneath the cupola windows as you peer down. Then you turn and look at the woman floating next to you. You and your wife are on the most far-out honeymoon of all time. This is the vision of the Inspiration Mars Foundation, headed by former NASA engineer, investment guru, and pioneering space tourist Dennis Tito. (In 2001 he spent around $20 million for eight days aboard the ISS.) Tito's group aims to take advantage of a planetary alignment in 2018 that occurs every 15 years. It will allow a spacecraft to travel from Earth to Mars and back on a free-return trajectory—that is, without burning any



propellant. Inspiration Mars will start accepting applications next year for a 501-day mission that will swing within 100 miles of the Martian surface. The group is planning to select a married couple, perhaps newlyweds, in the interest of psychological compatibility. "Inspiration Mars estimates it needs to raise $1 billion to $2 billion. We're laying the groundwork to do things that were once considered inconceivable, like go to other planets," says Teal Group's Marco Caceres.

If circling Mars doesn't sound sufficiently ambitious, consider Mars One, a Dutch nonprofit that aims to land four volunteers on Mars in 2023—and leave them there. As part of the proposed $6 billion program, Mars One will dispatch robotic missions to pave the way, the first departing in 2016. So far, 200,000 applicants have signed up for the 2023 trip. Would-be colonists from more than 140 countries registered; Americans make up the biggest contingent, at 24 percent. **PopMech**

THE 10 BEST SCI-FI MOVIES

SCIENTIST APPROVED!

BY JOE PAPPALARDO



+ THE 5 WORST!

EVER!

AS CHOSEN BY THE REAL* EXPERTS

Can a scientist watch a sci-fi movie and believe that it's good, even if it bends the laws of nature? The answer is yes—to a degree. "We can't count on science fiction to always get the science right," says Sidney Perkowitz, professor emeritus of physics, Emory University. "But we can count on it to generate excitement and interest in viewers." Perkowitz is among dozens of scientists and engineers we polled on their favorite sci-fi movies. Their opinions differed, of course, but a consensus emerged: A sci-fi film can be counted among the best if it has both scientific plausibility and cinematic merit. And if a movie has neither, well, see p. 86.

PHOTOGRAPH BY GREGORY REID



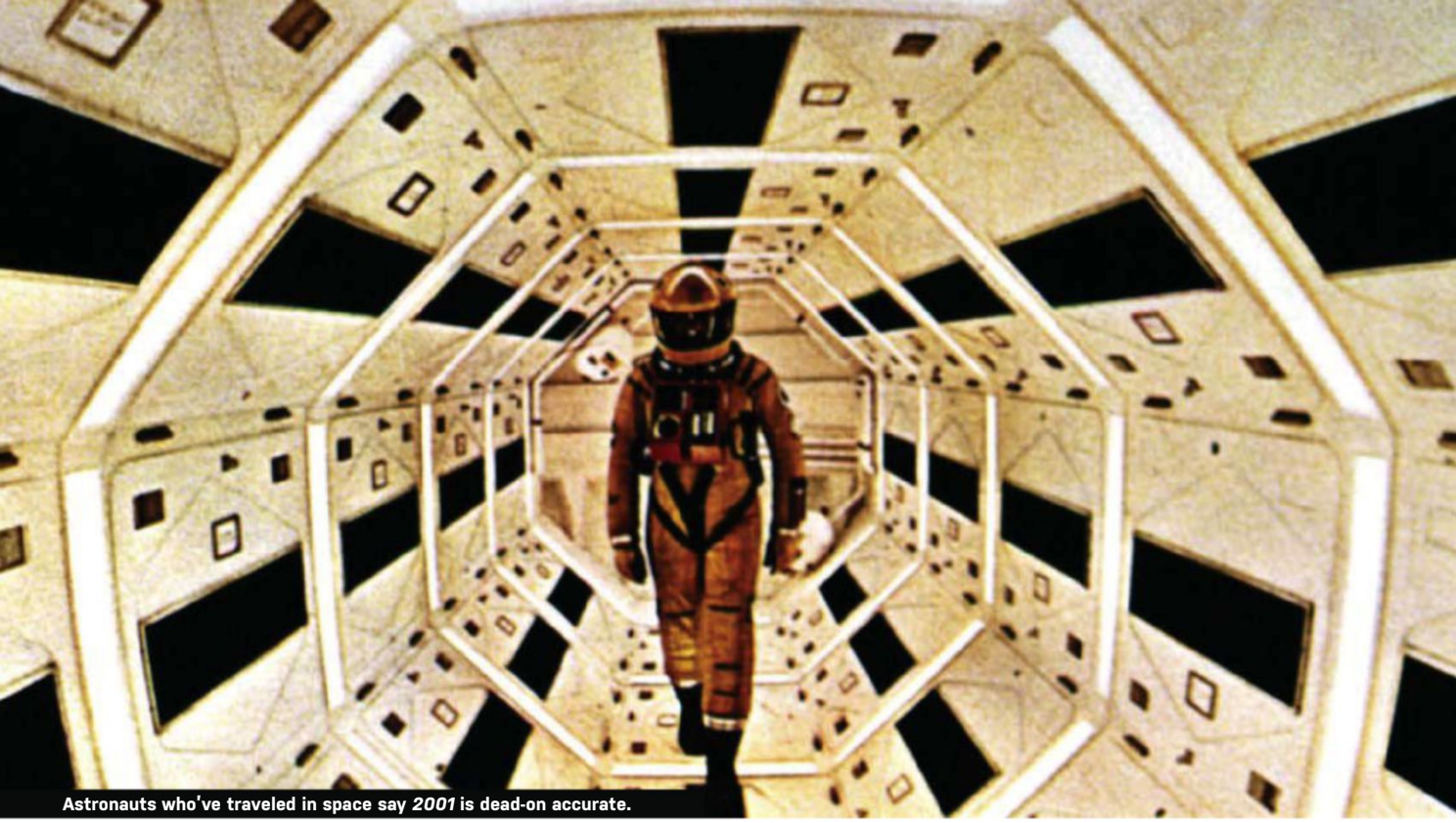
Director Stanley Kubrick ▶

No.1

2001: A Space Odyssey (1968)

This film elevated sci-fi movies from rubber-suit monster flicks to credible portrayals of the unknowns of space exploration and existence. The plot of the movie and of the concurrently released novel follows a mission to Jupiter and its discovery of an ancient monolith that may hold the key to human evolution. "*2001* is painstakingly realistic, doing its best to actually depict a plausible lunar colony and manned expedition to Jupiter," says Anders Sandberg, a research fellow at Oxford University's Future of Humanity Institute. "When I first saw it, as a teenager, I already knew the outline, but I was more fascinated the longer I watched." The impression lasted. "I always try to have a cosmic perspective: What would the Monolith do?" The movie's depiction of the hardware and living condi-

*ACTUAL SCIENTISTS AND ENGINEERS



Astronauts who've traveled in space say *2001* is dead-on accurate.

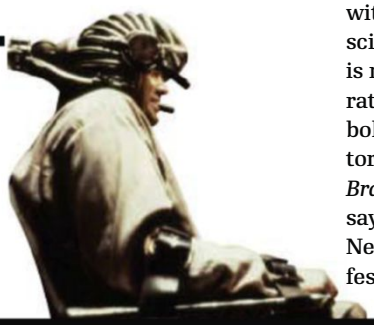
tions of space is regarded as the best representation of spaceflight and how we might survive off the planet. Director Stanley Kubrick "got so much right, it's amazing," says Leroy Chiao, who flew three NASA shuttle flights and spent seven months on the International Space Station. But the trippy, mind-bending closing sequence—when mission commander Dave Bowman enters the Monolith—confused Chiao at first. "I was puzzled and intrigued, because I had not read the book," he says. "It made a lot more sense afterward."

No. 2
The Matrix (1999)

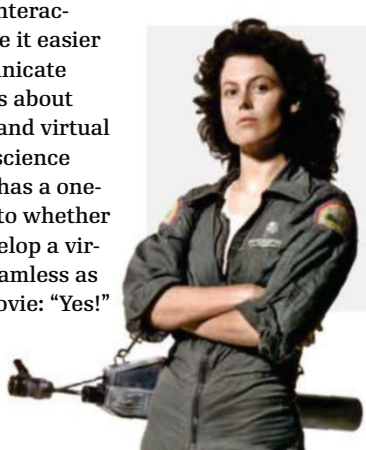
Wouldn't it be great if an action hero weren't bound by the laws of physics? The protagonist of *The Matrix,* a wan hacker named Neo, discovers that his world is a virtual construct set up by hostile robots who feast on human electrical energy. "*The Matrix* brought virtual reality into the public eye," says Jeremy Bailenson, cofounder of Stanford University's Virtual Human Interaction Lab. "It made it easier for me to communicate research findings about avatars, agents, and virtual reality with nonscience folk." Bailenson has a one-word answer as to whether humans will develop a virtual reality as seamless as the one in the movie: "Yes!"

No. 3
Brazil (1985)

Sam Lowry (below) is a civil servant in a bleak, dystopian world that treats individuals like mail in a post office. Sam's fantasy life of rescuing imperiled women becomes a little too real when he meets a subversive female truck driver and runs afoul of the automated, dehumanizing system around him. The film strikes a chord with researchers not for its scientific fidelity—its tech is more absurd than accurate—but, rather, because it boldly imagines a trajectory of the future. "I saw *Brazil* and was in shock," says Mitchell Joachim, a New York University professor and cofounder of the



PHOTOGRAPHS BY EVERETT COLLECTION (FILM STILLS)



No. 4
Alien (1979)

Sigourney Weaver (left) proved that a woman can be a badass sci-fi action hero. But our experts saw the gooey, exoskeletal villain—which uses living humans as hosts for its nasty progeny—as a pioneer of fictional biology. "The Alien franchise bases its xenomorph life cycle on parasitic wasps on Earth," says Terry Johnson, a bioengineering researcher at the University of California, Berkeley. "It's a pleasure to see a film that acknowledges just how weird life can be."



Stars of *WALL-E* (left), *Jurassic Park* (below), and *The Matrix*.

urban design think tank Terreform ONE. "It's dreamy and filled with irony in a technological society gone south. But the message is about our shared human goal of wishing for a better place." The film's dramatic landscapes, which feature cities that seem designed to strip individuals of their identities, influenced him personally: "I became an architect who works on cities of the future."

No. 5
Fantastic Voyage (1966)

A miniature spacecraft and crew are injected into a comatose scientist to remove a life-threatening blood clot, so that he can survive to share vital secrets. The movie's lavishly depicted workings of the human body garnered two Academy Awards and three additional nominations—and got James Giordano thinking about medicine at the tiniest scale. Now a professor of neuroscience at Georgetown University, Giordano examines the mechanics of the brain's response to pain. "The film has been a lifelong inspiration for me to work on developing neurotechnology," he says. David Carroll, director of the Center for Nanotechnology and Molecular Materials at Wake Forest University, says that the movie's minuscule technology, although physically impossible, is echoed in his current work. "It's exactly what we are working on: Injecting nanobots that find a cancerous tumor, tell us when they have found it, and destroy it," he says. Now that's fantastic.



"I WAS HAPPY THE [*JURASSIC PARK*] CHARACTER BASED ON ME WASN'T EATEN." — *JACK HORNER, PALEONTOLOGIST*

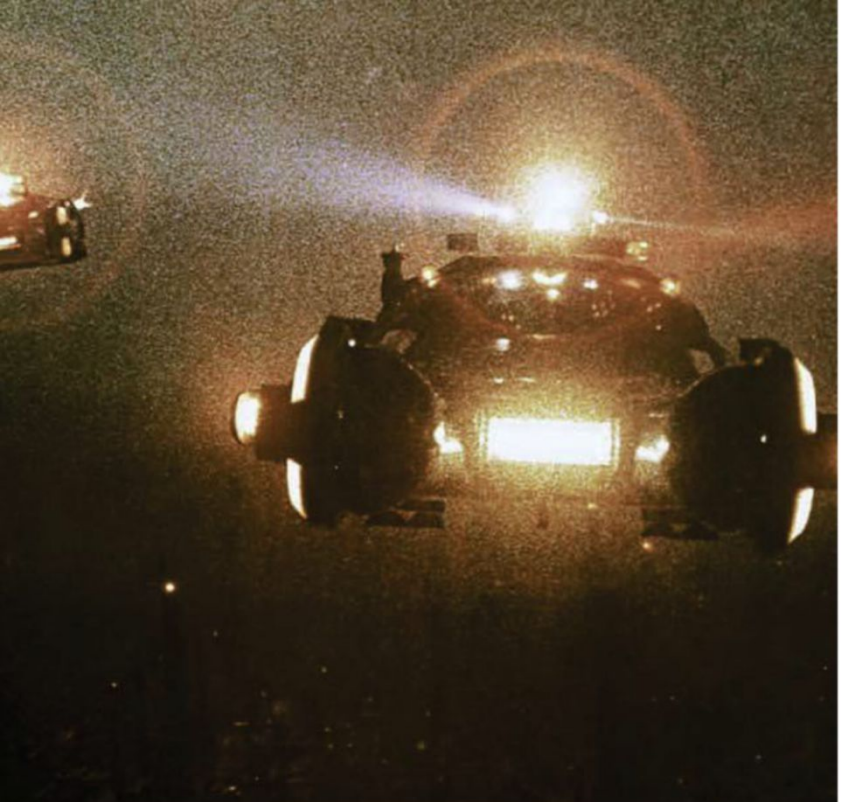
FANTASTIC VOYAGE

"WE GET BOGGED DOWN IN THE IDEA OF ACCURACY WHEN WE JUDGE MOVIE SCIENCE. I PREFER THE TERMS AUTHENTICITY AND PLAUSIBILITY. I MEASURE A SCI-FI FILM BY HOW EFFECTIVELY IT USES SCIENCE TO TELL A STORY." — *DAVID KIRBY, UNIVERSITY OF MANCHESTER, AUTHOR,* LAB COATS IN HOLLYWOOD



No. 6
WALL-E (2008)

Meet WALL-E (Waste Allocation Load Lifter—Earth-Class), a robot left on Earth to clean up after bloated humans who have relocated to space stations. When WALL-E shows a living plant to his love interest, EVE (Extraterrestrial Vegetation Evaluator), the pair trigger





Blade Runner **(above) is creepy, while** ***Star Wars*** **(center) is goofy.**

"SCIENCE-FICTION MOVIES DO LITTLE FOR SCIENCE BUT A LOT FOR TECHNOLOGY. THEY OFFER VISIONS OF WHAT COULD BE AND POSE PROBLEMS FOR US TO SOLVE."
— *MASON PECK, CHIEF TECHNOLOGIST, NASA*

events that lead to the repopulation of the planet. Steven Schlozman, Harvard Medical School's codirector of medical student education in psychiatry, lauds the movie for being ahead of its time. "These films hold mirrors up to our conceptualization of self, and then distort what we see," he says. "In *WALL-E,* do you feel closer to the robot or to the humans? The capacity to tolerate a version of yourself that you might not like is central to recent neurobiological ideas, such as theory of mind and mirror neurons."

No. 7
Jurassic Park (1993)

Jurassic Park floated an idea—that dinosaur DNA could be drawn from insects trapped in amber—that was first accepted as reality. But discerning scientific minds pointed out that the prehistoric monsters' genetic strands would have degraded long before the movie showed their retrieval. "*Jurassic Park* depicts science we *wish* could be true," says Jack Horner, the paleontologist model for the movie's lead. David Penney, University of Manchester paleobiologist, says he watches the movie to this day and likes that it makes his research look "sexy."

No. 8
Blade Runner (1982)

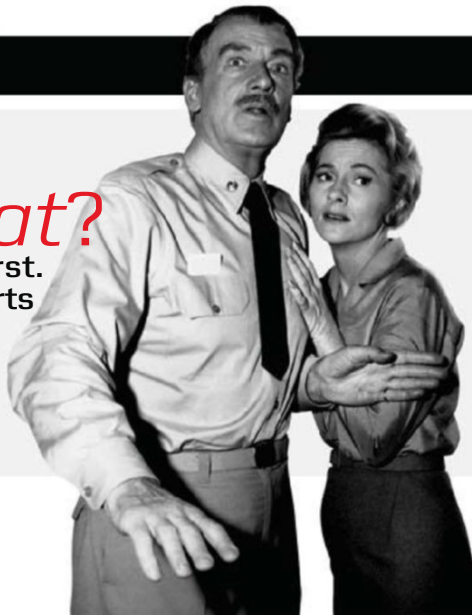
Humanlike robots can be a good thing (see "Battle of the Lifesaving Robots," page 19). But in this sci-fi classic, androids called replicants get too lifelike for comfort and are banished to space colonies. If they escape and return to Earth, special cops, or blade runners, who can tell humans from replicants, hunt them down and neutralize them. Our experts give the film high marks, in part, for its humanization of advanced robots. "*Blade Runner* has probably done more to ready the world for artificial life than [any other film]," says Daniel Novy, a scientist at MIT's Media Lab. "Inspiration is important, even at the expense of some accuracy."

ILLUSTRATIONS BY MARTIN LAKSMAN



Sci-*What?*

The 5 worst. Our experts have spoken!







Thanks, *War of the Worlds,* for the specter of suction-cup fingertips!

No. 9
Star Wars (1977)

It's futuristic fantasy with a hammy space-opera plot borrowed from spaghetti westerns and samurai films. But scientists love *Star Wars* just as much as everyone else. "Nothing so fantastical yet inspiring had been on the big screen before," says Aaron Blaisdell, a UCLA professor of behavioral neuroscience, who first saw the movie at age 9. Siddhartha Srinivasa, of Carnegie Mellon's Robotics Institute, also saw *Star Wars* as a boy. Now he's building a servant robot partially inspired by C-3PO. "Fiction stimulates science as it points to a future we should strive for," he says.



No. 10
The War of the Worlds (1953)

This cinematic update of the 1898 H.G. Wells novel about a violent Martian invasion was particularly jarring because of the timing of its debut—namely, when World War II weaponeering prowess and the threat of nuclear attack were very much part of the national consciousness. The idea that humans could be vastly overmatched in battle by aliens terrified viewers and set their imaginations spinning. "I was sick all night long," Seth Shostak, the senior astronomer with the SETI (Search for Extraterrestrial Intelligence) Institute, says of his first viewing of the film. "That's the mark of a film that makes a difference." **PopMech**

Voyage to the Bottom of the Sea (1961)

A sub dives in the Arctic Ocean to flee an Earth-scorching fire. "The ice cap melts, and ice chunks *sink* and hit the sub," says Stanford University paleontologist Kevin Boyce. Sinking ice? Weird.

•

Armageddon (1998)

A doomsday asteroid is diverted, but science gets crushed. "Rain hitting the windshield of a spaceship on an asteroid wins the award for most unrealistic moment in sci-fi history," says Pepperdine University psychologist Jessica Cail.

•

The Phantom Menace (1999)

The *Star Wars* prequel didn't just rile diehard fans. MIT's Daniel Novy identifies the main culprits as midichlorians, intelligent microorganisms that mediate the Force. With that mystery solved, interest in *Star Wars* withers.

•

The Core (2003)

To save humanity, scientists drill to inner Earth in a vessel protected by "unobtainium." "*The Core* gets more science wrong than almost any other film I know," says Emory University physicist Sidney Perkowitz. Blunder: The scene where a character survives hellishly high temperatures inside Earth.

•

2012 (2009)

The sun's neutrinos "mutate," alter the Earth's core, and the Mayan apocalypse looms. Error: Neutrinos don't mutate. "The science is implausible, the movie boring," says University of Manchester's David Kirby.

Additional reporting by Darren Orf & Will Dietrich-Egensteiner





SHIP OF DREAMS

WITH TECHNOLOGY BORROWED FROM SUBMARINES, A SCRAPPY CALIFORNIA COMPANY IS ATTEMPTING TO RESURRECT A CENTURY-LONG DREAM OF BUILDING HUGE AIRSHIPS TO CARRY FREIGHT—AND PEOPLE—ACROSS THE SKIES. BY KALEE THOMPSON

PHOTOGRAPHS BY NATHANIEL WOOD

The Aeroscraft prototype, seen here in its hangar in Tustin, Calif., could herald a new era in airships.

On a Thursday morning last January a team of engineers gathered in a hulking concrete hangar in the Orange County suburb of Tustin, Calif. The hangar—once used to house massive antisubmarine blimps that patrolled the coast during World War II—was an imposing sight, an anachronism amid the manicured pods of suburban town homes and outdoor malls nearby. The vehicle inside, the prototype for an airship known as the Aeroscraft, was just as much of a spectacle: 266 feet long and 110 feet wide, with a rigid aluminum and carbon-fiber skeleton covered by a thin skin of shimmery mylar composite material. Squat and bulbous, the craft looked like a majestic whale shark, a gentle giant of the seas.

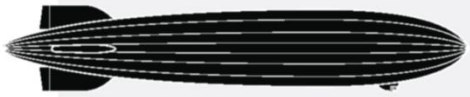
A few of the engineers crowded into the compact glass-and-aluminum cockpit suspended below the hull. At the push of a button, the imposing airship lifted from the concrete, becoming airborne for the first time. It rose 10, 20, and finally 35 feet in the air. Then engineers shifted the ship into descent mode and the Aeroscraft settled back to the floor.

•

The January test was modest: The engineers called it a first float rather than a first flight. The first test outside the hangar, which occurred in early September, after a necessary Federal Aviation Administration certification was granted, was perhaps less ambitious—the ship remained tethered as it rose about 20 feet in the air. But the vision behind the Aeroscraft is expansive. Its inventor, Kazakhstan-born engineer Igor Pasternak, has dreamed since childhood of building huge airships that would crisscross the skies ferrying freight. He is just one in a long line of believers, stretching back at least as far as the German Count Ferdinand von Zeppelin, who built the first rigid airship in the 1890s. "That idea has been around for over a hundred years," says John Hansman, a professor of aeronautics at Massachusetts Institute of Technology and the director of the university's International Center for Air Transportation. By the mid-20th century, lighter-than-air craft had completed more than 150 trans-Atlantic passenger trips. During World War II American airships carried supplies, bombs, even planes. But then the technology stalled—for good reason, Hansman says. "Once airplanes could make long-range flights and carry a lot of payload, the market quickly shifted."

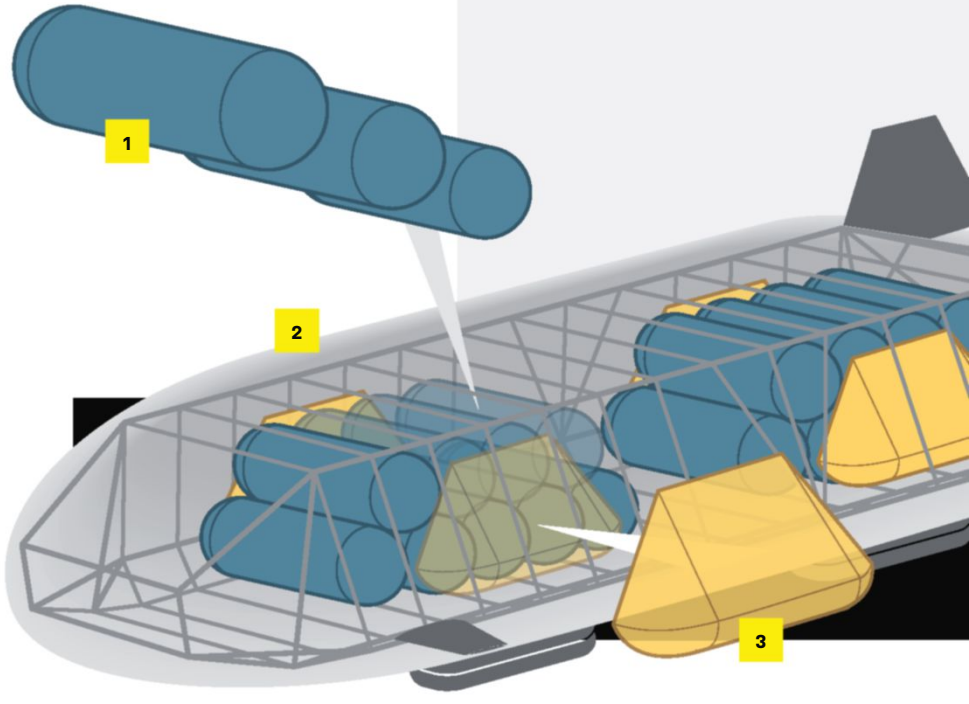
Today most lighter-than-air ships, or aerostats, are blimps—basically oversize balloons that serve primarily as flying billboards. However, the dream of rigid airships carrying freight refuses to die. In the past decade no fewer than a half-dozen companies have invested millions toward the goal. So far they have little to show for it. But Pasternak and his partners believe they will succeed where others have failed, thanks mainly to the Aeroscraft's innovative buoyancy system. Tony Tether ran the military's DARPA (Defense Advanced Research Projects Agency) program from 2001 to 2009 and now serves on Aeros's advisory board. "It's as big a deal as Kitty Hawk," he says without irony. "This will change the way we deliver cargo, and maybe people, around the world."

***Hindenburg*: 804 feet**



HOW IT WORKS

The Aeroscraft uses a buoyancy system called COSH, for Control of Static Heaviness, which is inspired by submarine technology. The system eliminates the need for runways and ground crews. That could make this airship ideally suited for moving heavy cargo to remote locations.



Planned Aeros production model: 555 feet

Boeing 747-8 freighter: 250 feet

Goodyear blimp: 192 feet

DIAGRAM BY **MARTIN LAKSMAN**



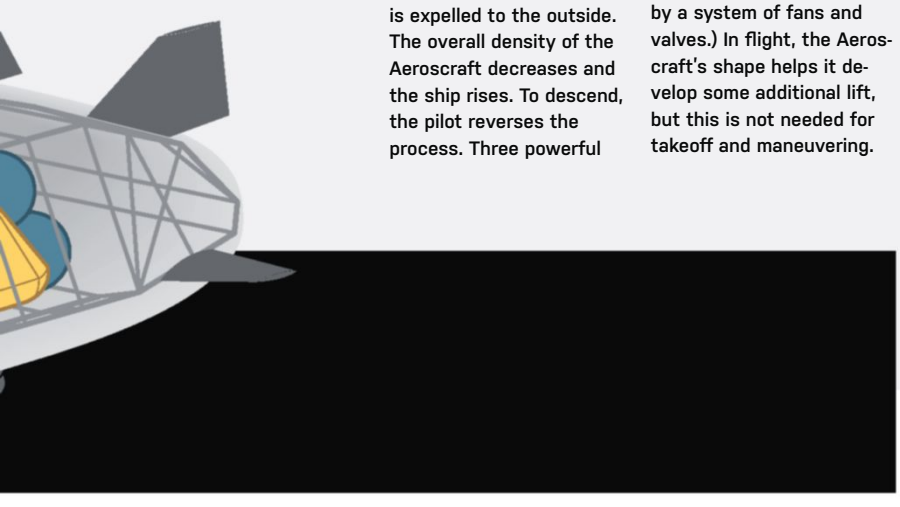
GIANTS OF THE SKY

The bigger the airship, the more efficient it is. At 555 feet, the first Aeros production model will dwarf cargo airplanes; the company hopes eventually to build 770-foot-long models that could carry 250 tons of freight—twice as much as a 747-8 freighter.

BUOYANCY

Aeros's first planned production model will have 18 helium tanks (1). To increase lift, the pilot releases helium, which is much lighter than air, from the tanks into the large envelope (2) that makes up most of the volume of the ship (cargo hold not shown). This applies pressure to the four large air bladders (3) located along the sides of the Aeroscraft.

As the bladders are squeezed, much of this air is expelled to the outside. The overall density of the Aeroscraft decreases and the ship rises. To descend, the pilot reverses the process. Three powerful compressors (not shown) force the helium from the envelope back into the storage tanks. A partial vacuum develops inside the envelope and the airbags expand, pulling in dense air from outside the ship. The Aeroscraft sinks. (The transfer of air is assisted by a system of fans and valves.) In flight, the Aeroscraft's shape helps it develop some additional lift, but this is not needed for takeoff and maneuvering.





Aeros founder Igor Pasternak: "Airships are beautiful, but it's really about a new capability for mankind."

When I visited the Tustin hangar in May, the Aeroscraft was skinned like a fish. The flexible composite exterior draped the lower frame, while, above, the complex skeleton and a row of car-size helium tanks were left exposed. The tanks lie at the heart of the Aeroscraft's buoyancy system, which is based on submarine technology. One of the lead engineers, 32-year-old Tim Kenny, walked me through it. Submarines draw in seawater to descend, then pump it out to increase buoyancy and rise toward the surface. The Aeroscraft works the same way, he explained, but it uses air rather than water.

Kenny showed me one of the tanks. Empty, it weighed 500 pounds. Right now, filled with helium at low pressure like a child's balloon, it needed an anchor. I was able to push the huge melon out of place with two fingers. Once it is pumped full of highly compressed helium, Kenny explained, each tank becomes far heavier, like a full propane tank for a backyard grill.

Next Kenny pointed out several large, white expansion bladders. When the airship's helium is compressed inside the tanks, a partial vacuum develops around the bladders, and they fill with air from outside the craft. Buoyancy drops and the ship descends. "Once the tanks release that helium back into the main envelope, the expansion bladders deflate to neutralize the internal pressure of the airship and force the air—the ballast—outside the aircraft," he said. The ship rises.

Conventional airships need to take on ballast (typically water) after delivering their cargo to compensate for the lost weight. They need ground crews and runways, though much shorter ones than an airplane uses. An operating Aeroscraft would require none of that—or any ground infrastructure at all. The machine could fly to a roadless region in the Arctic, settle down on the tundra to unload mining equipment from its huge cargo compartment, and take off again on its own. It could deliver immense wind turbines slung below its hull and hover like a helicopter while bearing loads normally associated with ocean freighters.

The biggest challenge in achieving this capability has been the buoyancy system's weight—the heavy tanks, pumps, and hull structure. "People did not believe you could do all of that and end up with something that could float," Tether says. To solve the problem,



Aeros engineers became obsessive ounce-watchers. During my tour Kenny handed me a 6-foot piece of carbon-fiber and aluminum truss, the material that makes up the airship's skeleton. It was disconcertingly light.

Even MIT's Hansman, who remains skeptical of the airship industry's future, believes the technology could work. "It's definitely possible. There are no physics that would prevent them from doing what they want to do. It's just hard—hard technically, in terms of financing and having the persistence to get there."

•

Igor Pasternak was wearing a pinstripe suit, a pink tie, and sunburst-patterned suspenders beneath a wild mop of gray hair when we met at his office at the headquarters of Worldwide Aeros—two buildings tucked into an office park in suburban Montebello, Calif. He told me he had been obsessed with airships from the time he was 10 years old. "I've been doing this all my life, nothing else," he said.

Pasternak was born in what is today Kazakhstan and grew up in Ukraine, the son of Soviet civil engineers. After graduating in the 1980s with an advanced engineering degree, he started building aerostats for advertising and environmental monitoring, as Mikhail Gorbachev's perestroika initiative got started. By the early 1990s he had 60 employees and was selling and leasing 3000 oversize, unmanned balloons throughout the Soviet bloc and beyond. Everything, he says, came from experimentation. "I was creating technology. You don't have textbooks, you don't have examples."

Then the Soviet Union collapsed. "There was only one decision," Pasternak said. "To build something like the Aeroscraft, you need to be in America." He emigrated in 1994 and spent his first few months in New York. One day he saw then President Clinton on the news, announcing the closure of California's Castle Air Force Base, a former B-52 testing site. By the next year Pasternak and a handful of employees with heavy accents were building balloons in a facility still redolent of the Cold War. "It was a bunch of Russians and B-52s—same hangar!"

Pasternak built manned airships for advertisers—the 1996 Atlanta Olympics, MasterCard, tourism boards. After Sept. 11 the in-sky advertising market dried up, but the Department of Defense started looking into aerostats. Pasternak and Lockheed Martin both secured multimillion-dollar design-feasibility grants for a program called Walrus HULA (Hybrid Ultra Large Aircraft), which sought to develop an airship that could cover 12,000 nautical miles in seven days, with a payload capability of at least 450 tons. The military didn't pursue Walrus, but it later initiated a pro-





The cockpit, which accommodates two pilots, is suspended beneath the hull (left). The ship's Air Cushion Take-off/Landing System (ACTLS) creates a vacuum to anchor the ship to the ground (below). Opposite: The Aeroscraft underwent tethered flight testing on Sept. 7, 2013.

gram called the Long Endurance Multi-Intelligence Vehicle (LEMV), which funded a Northrop Grumman design before being canceled in early 2013. During this period of on-and-off military spending on airships, Pasternak managed to acquire $35 million in government money to build his Aeroscraft, while assembling a scrappy team of engineers.

"You need to know how to hold a screwdriver," he told me—not just how to run computer modeling programs. "It's mechanics." As a second requirement, Pasternak hires only employees who have virtually no experience with airships. "We're not hiring anyone from mainstream industry," Pasternak said. "We are grabbing the people who don't already know what is impossible."

•

The Aeroscraft in Pasternak's hangar is the biggest rigid airship built in the United States since the 1940s. But it's tiny compared with the transport vehicle that Pasternak envisions. He sees, first, a fleet of 555-foot-long airships that he says will carry 66 tons in the cargo hold. Eventually Pasternak plans to launch a version that could haul 250 tons. It would be 770 feet long, three times the length of a Boeing 747.

Bigger is better is a key tenet of airship transport. It all comes down to something called the square-cube law, explains aerospace engineer Robert Boyd, head of the hybrid airship program at Lockheed Martin. "If you take an airship and you double its length, that makes the surface area go up by roughly four; that's the square," Boyd explains. "And it makes the volume go up by roughly eight, which is the cube." The square is associated with the bad things—drag and weight. The cube is what's good: A bigger volume of helium means more lift. "So, as you get larger, the good things grow much faster than the bad things," Boyd says, and that brings a huge benefit in efficiency.

Lockheed Martin's own prototype, developed independently of any government contract, is a 120-foot airship called the P-791. The company's largest proposed version would be 800 or 900 feet long and haul up to 500 tons. Large airships like that could transport cargo far more cheaply than fixed-wing planes, according to a study prepared a decade ago by the Pentagon's U.S. Transportation Command. Airships would ultimately cost about a third as much to build as a 747 and would use a third as much fuel. Even airships that require a ground crew and runway are less infrastructure-intensive than large fixed-wing aircraft.

Of course, airships have weaknesses as well. The Aeroscraft's cruising speed will be about 115 mph, versus more than 500 mph for an airplane such as the 747. And bad weather presents unique challenges. An airship of any design is "probably less sensitive [than airplanes] to things like turbulence because it's so big—kind of like an ocean liner as compared with a rowboat," MIT's Hansman says. "But it's got a much more difficult time dealing with wind and turbulence on takeoff and landing." The full-scale Aeroscraft is designed to operate in winds up to 40 knots, but it can't outrun bad weather the way an airplane often can—the operators would have to rely on weather forecasts and conservative planning. That would be a challenge in the Arctic, where violent storms can last for days.

There are business challenges, as well. After the P-791's successful test flight, there was talk of developing larger versions of the ship to carry cargo, but, so far, the prototype

SHIP OF DREAMS
CONTINUED ON PAGE 129


IT'S GOT GUTS.
YOU GET THE GLORY.
ARCTIC CAT
SHARE OUR PASSION.™
The Wildcat™ X with 90+ horsepower. There's no competition when there's no comparison. It's an unmatchable combination: The race-tuned V-Twin engine. The 5-link rear suspension. The industry's only exoskeleton frame. Make the desert your domain. To find your nearest dealer, go to arcticcat.com
WILDCAT NOTHING'S AS WILD.
ROVs can be hazardous to operate. Improper use can cause severe injury or death. Each rider must wear a seat belt, approved helmet, eye protection and protective gear. Each rider must use handholds/steering wheel and stay completely inside the vehicle. Each rider must be able to sit with their back against the seat, feet flat on floor and hands on handholds/steering wheel and must read and understand the operator's manual before riding. Follow all instructions and warnings. Avoid abrupt maneuvers, hard acceleration when turning, and sidehilling. Avoid paved surfaces. Slow down before entering a turn. Don't operate on public roads unless designated for off-highway vehicle access — collisions with cars and trucks can occur. Never engage in stunt driving. Never drive or ride under influence of alcohol or drugs. Avoid excessive speeds and be particularly careful on difficult terrain. All ROV operators must have a valid driver's license. No operators under age 16. Never carry a passenger in the cargo box or exceed seating capacity. Do not shoot from or lean firearms or bows against the ROV. Arctic Cat recommends that all riders take a training course. For safety and training information, go to www.rohva.org. Along with concerned conservationists everywhere, Arctic Cat urges you to "Tread Lightly" on public and private lands. Ride only on designated areas or trails. Preserve your future riding opportunities by showing respect for the environment, local laws and the rights of others when riding. Arctic Cat,® Share Our Passion™ and Wildcat™ are trademarks or registered trademarks of Arctic Cat Inc. ©2013 Arctic Cat Sales Inc., Thief River Falls, MN 56701. Arctic Cat ATVs and Side by Sides (ROVs) are world-class products from Arctic Cat Inc.
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Popular Mechanics

W weekend



Cutting down your own tree and hauling it home makes the holidays bright.

AUTO Upgrade your car audio with our simple step-by-step Bluetooth install. **p. 96**

HOME Build toys from scratch to delight kids and satisfy your inner child. **p. 104**

TECH Keys become optional as we enter the era of the digital door lock. **p. 120**

diy

Auto

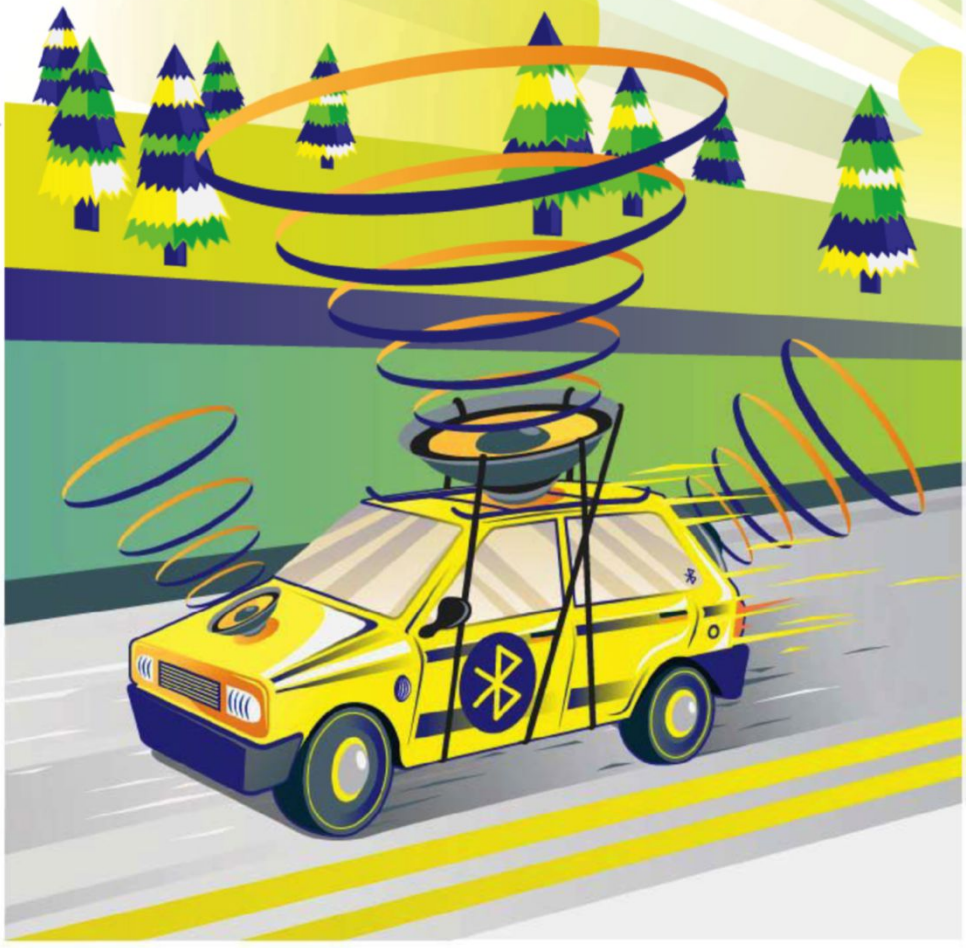
WINTER EMERGENCY KIT
BELT SQUEAL
DIPPING A TOE-IN
COLD CASE

Degree of Difficulty 5/10

Saturday Mechanic:

BLUETOOTH IN ANY RADIO

YOU CAN STREAM MUSIC THROUGH YOUR RADIO AND KEEP THAT ORIGINAL-EQUIPMENT LOOK—FOR LESS THAN THE COST OF A NEW RECEIVER. *BY MURILEE MARTIN*



Bluetooth audio is common in new cars, but if your ride is a few years old you might not be able to stream audio through the radio. Other options exist: Your car may have an auxiliary input that connects any audio source via a 3.5-mm (⅛-inch) minijack; older cars might even take a cassette adapter. But both of these solutions add clutter to the interior. Here's a cheap way to put wireless audio in any car without adding unsightly cords or even changing the appearance of the factory audio system.

THE HOW-TO

The general concept is simple, but you need to be comfortable with taking your interior apart and working under the dashboard. Here's how it's done:

- **Remove the radio:** Disassemble the necessary trim and pull the stereo out of its mount to expose the rear of the head unit. This may require a specialized stereo-removal tool. For help on this, consult your car's service manual or check online forums. Take pictures of the process so you can put things back together in the correct order.
- **Connect the modulator:** Remove the antenna cable. Then plug the wired FM modulator into

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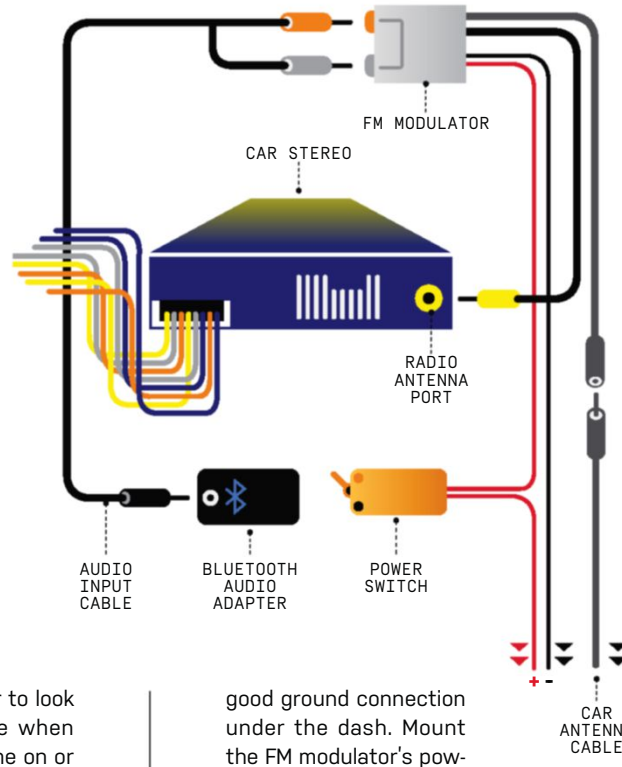
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ROCKWELL

HISTORY

ILLUSTRATION BY **PARQUERAMA**

the antenna connection on the radio, and the antenna cable into the FM modulator. If the FM modulator has a frequency selector, choose the frequency with the least interference in your area. Some cars (such as GM and Nissan models starting in the late 1980s, and plenty of others in the 21st century) use oddball proprietary antenna connectors on factory radios instead of the typical Motorola connector. If this is the case with your car, you may need to buy an antenna-connector adapter.



Find power: Use a voltmeter or circuit tester to look for a wire that has juice when the ignition switch is in the on or accessory position, and is dead when the key is switched off. The radio circuit is your best bet. Here again, your car's service manual or the Internet will help a lot.

Connect power: Using splice connectors, attach the wire from the power switch that came with the FM modulator to the power source you located in the previous step. If the modulator does not have an inline fuse, we recommend adding one to the positive wire. Connect the ground wire from the FM modulator to a good ground connection under the dash. Mount the FM modulator's power switch in a convenient location, near the radio or center console.

Tidying up: Plug the RCA connectors of the audio input cable into the FM modulator. Route the end with the 3.5-mm plug to a location inside the glovebox, center console, or other easily accessed but hidden location. Secure the FM modulator under the dash with zip ties. Gather the loose wires with additional zip ties. Don't make it too tight—you don't want to crimp any wires.

Test the audio: Turn the ignition on, power up the FM modulator, and connect an audio device to the 3.5-mm plug; tune the radio to the FM modulator's frequency, and make sure you're getting a good audio signal.

Add Bluetooth: Remove your test connection. Charge your Bluetooth adapter and pair it with your smartphone, tablet, or MP3 player. Connect the 3.5-mm plug to the Bluetooth adapter. You should be able to feed audio through your radio with Bluetooth now.

Bonus step: If you want to get fancy, hardwire a USB car charger into the same power source you used in "Connect power" and keep the Bluetooth adapter plugged in at all times. This will require disassembling a USB car charger and soldering wires to the charger's power circuit. If you're not up for that, keep a charger in the car and recharge the Bluetooth adapter when needed—that's what we did.

Replace trim: Put all the panels you removed to access the radio back in place. Congratulations—now you can stream Bluetooth audio.

Shopping List

Wired FM modulator: Be sure it includes antenna connection cables, as well as a power switch. ISimple's IS31 Antenna Bypass FM Modulator has everything you need for about $30, but we found plenty of generic models on eBay for under $25.

Audio input cable: 3.5-mm stereo male to dual RCA stereo male. Stores sell these for less than $10. You can find them online for even less.

Bluetooth A2DP adapter: Look for one with a 3.5-mm input and USB charging. A good example is the EDUP EP-B3503, which goes for about $24. Again, no-name units can be found for less on eBay.

USB car-charger adapter: This charges the Bluetooth adapter. Don't pay more than $5 for one online.

Zip ties For gathering up dangling wires.

Splice connectors: We like this style of connector because it's almost foolproof, ensuring that you have to do the job only once.

Tools: Aside from the basics (screwdrivers, wrenches), you'll need

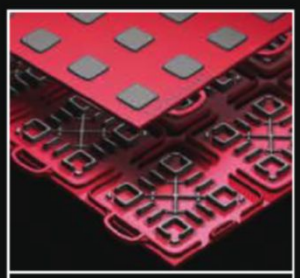
- Voltmeter or 12-volt circuit tester
- Wire strippers

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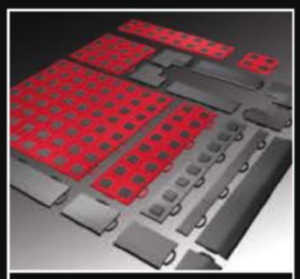
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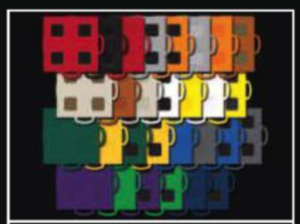
The Rubber Goes Through



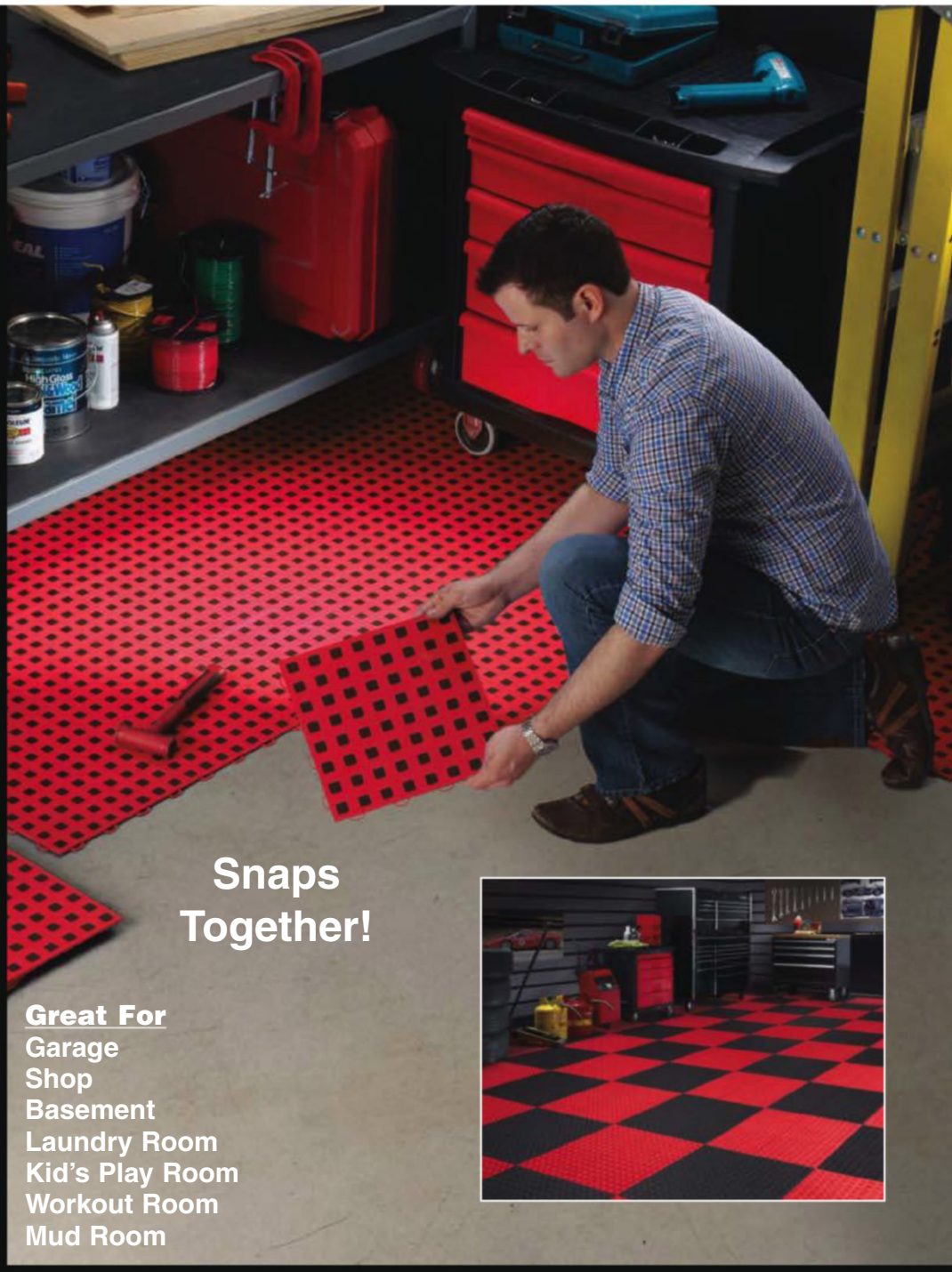
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A few extra items in your emergency kit during winter months make a big difference if you encounter trouble.

Car Clinic

BY
BEN WOJDYLA

PHOTOGRAPH BY
PHILIP FRIEDMAN

Take On Winter

My daughter just started driving on her own and I want to make sure she has the proper gear in the trunk to get through a winter emergency. What should I make sure she has?

Q+A

If you already have an emergency kit, well done. Essentials such as first-aid supplies, jumper cables, gloves, a flashlight, duct tape, a tow strap, and some simple tools should already be in your trunk—if not for daily driving, then at least when you set out on a road trip. Here are some winter-specific items to include for times when the roads are covered in slush.

Snow Socks: When you unexpectedly need extra traction, snow socks are a space-saving, temporary alternative to snow chains. These fabric doughnuts fit easily over the drive tires and can increase grip enough to extricate a stuck car or get it up a slippery hill.

Spare Phone Charger: The cellphone is your primary means of rescue in today's interconnected world. But to reach help you need juice: A charging cord is a good idea, but a hand-crank charger that works away from the car or when the car battery is dead is an even better one.

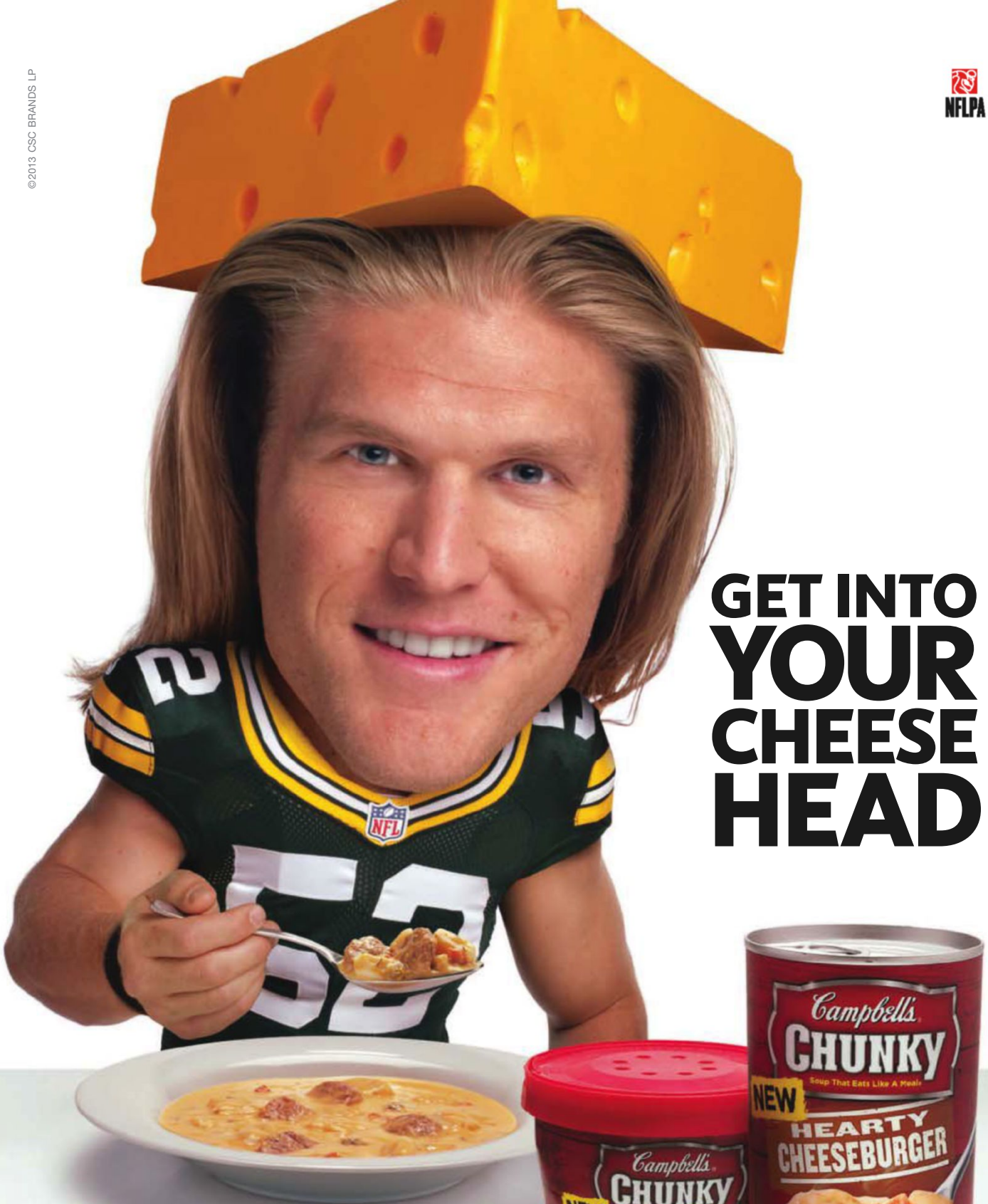
Hand Warmers and Wool Blanket: Your car provides shelter, but you don't want to run the engine—you have a limited amount of fuel and deadly exhaust may find its way into the cabin. To keep warm, use a blanket, supplemented by hand warmers when it gets really cold.

LED Flashers/Flares: Battery-powered lights work for hours and are great for alerting other drivers if your car is on the side of the road. Flares may seem antiquated, but the heat they put out prevents them from being obscured and buried by driving snow. Plus, in an extreme emergency they can be used to start a warming or signaling fire. Flares are usually sold in packs; make sure you have at least three sticks.

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Food and Drink:
It's exceptionally rare for anyone to be stranded during a winter blizzard for more than a day. Long-term rations aren't really necessary, but keeping a few energy bars and a plastic bottle or two of sugary energy drink wouldn't hurt. Why the latter? The electrolytes and sugars significantly lower the concoction's freezing point, ensuring you'll still have liquid when you need it.

Shovel:
While it might not look like much, a compact folding shovel is plenty big enough to use when digging your car out of the snow.

Windshield De-Icer:
An extra bottle of this could mean the difference between seeing the road and seeing yourself parked in a snow bank. Plus, in emergencies you can use the stuff to melt ice on the road or any frozen car parts.

All the Way Home

Every time I start my car there's a horrible squealing noise that doesn't seem to go away until the car warms up. A friend told me it's the power steering pump going bad but I'd like your take.

I'm not sure about your steering pump, but it doesn't have anything to do with that horrible noise. That is the sound of a serpentine belt getting old. As the belt ages the chemicals in the rubber evaporate and the material gets stiff and brittle, resulting in a loss of friction (needed to drive the accessories).

You can't buy just any replacement belt, though—it has to be the proper length and is usually specific to each car model. If that already sounds too intimidating, a shop should be able to install a new belt for less than an hour's worth of labor. But it's pretty easy to change the belt yourself.

Take a few photos of the routing that the belt follows through all the pulleys (there should also be a diagram on the bottom of the hood or on the radiator support) and find the belt tensioner. This spring-loaded arm has a free-spinning pulley on the end that keeps the belt taut. Sometimes the tension can be relieved by moving the pulley with a box-end or socket wrench; other times a special tool is needed (it can usually be rented at a parts store). Be careful when relieving the spring pressure and keep your hands out of harm's way. Pull out the old belt, put the new one in place, and carefully release the tensioner to tighten things back up. The car should be blissfully quiet once again.

Attack the Snow

I have a 2009 Honda Civic that I derisively refer to as the snow chicken because it doesn't do so well in the white stuff. What can I do to improve the car's performance in wintry conditions?

The single best option for improving winter traction is to invest in a set of winter tires. All-season tires are actually more like three-season tires. They can get you through a mild winter, but moderate-to-heavy snow requires specialized equipment. The No. 1 factor in a tire's grip is the rubber, and when the temperature drops below 40 F, regular tires get hard and slippery. Winter tires are constructed of rubber optimized to stay flexible in cold temperatures. And winter tires have specialized treads that are better at biting into hard-packed snow or eking out extra grip on ice. Buying a separate set of tires sounds expensive, but it's really not that bad. During the months you're driving on your winter tires, you're *not* putting any wear on your warm-weather set.

All Toe Up

Recently I bought a new set of tires and got an alignment. Within a few days the passenger-side rear

was bald down to the steel belts. The shop told me the "toe" had been improperly set, replaced the tire, and did another alignment. What exactly is toe?

Toe is the angle the tires point in or out from straight ahead. Imagine your feet are analogous to tires and point your toes together; in suspension lingo this is called toe-in. Now point your toes away from each other; this is called toe-out. The angle of toe affects the way the car feels going down the road as well as how it responds when you turn the steering wheel. Toe is always set the same left to right, but usually the front and rear axles have different specifications. Most cars have less than half a degree of toe-in or -out at all four corners, which is just enough to improve stability or handling (ideally both) without excessive tire wear. Toe is usually set by adjusting an eccentric bolt connected to the aptly named toe-control link, which nudges the alignment in or out. What happened with your car is that the passenger-side rear toe angle was accidentally set far out of spec, and the tire was being scrubbed across the road surface, which wore off the tread. **PopMech**

? GOT A CAR PROBLEM? ASK BEN ABOUT IT.

Send your questions to **pmautoclinic@hearst.com** or over Twitter at @PopMechAuto or to Car Clinic, Popular Mechanics, 300 W. 57th St., New York, NY 10019-5899. While we can't answer questions individually, problems of general interest will be discussed in the column.



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Forget sleek and subtle, the Stauer Colossus Hybrid is one tough timepiece…now for less than $50!

In designing the ***Colossus Hybrid Chronograph***, our instructions to the watchmaker were clear: build it as tough as a battleship and fill it full of surprises. Make it a hybrid, because it should work twice as hard as a regular watch. And make it look like a million bucks, because when you put it on, you should get excited about rolling up your sleeves. Mission accomplished.

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Home

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Build Your Own Children's Toy

SKIP THE HOLIDAY SHOPPING THIS YEAR. INSTEAD, CREATE SOMETHING MEANINGFUL FOR YOUR LITTLE ONES. *BY DAVID AGRELL*

After my daughter was born in May, I promised myself I'd build her an heirloom-quality toy—something more lasting than the cheap stuff that fills the stores this time of year. For help creating a toy that I'd be proud to give, I called Brian LaRossa, an award-winning illustrator and senior designer at Scholastic, the children's media company. He's also the father of twin boys, making him even more qualified to assist.

We arrived at this wooden dinosaur, which not only looks charming but also invites interaction. Because of the small parts, it'll be a few years before my daughter gets her hands on this. But when she does, she'll simply twist the parts to create lifelike poses. Best of all, this toy is easy to build with a few basic tools. And because the materials are affordable and available in bulk, we suggest you build more than one. After all, kids can never have too many friends.



RECOMMENDED TOOLS Miter saw / center punch / hand-screw clamp / drill press / 5⁄32" and 1⁄8" drill bits / 1", 3⁄4", and 1⁄2" Forstner bits / cordless drill / 100- and 180-grit sandpaper / utility knife / paintbrushes / rags

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Neck, Tail, and Leg Parts

Begin by cutting the dowel stock to the sizes provided in the Parts List on the next page. (For mitered pieces, the dimensions given are for the long side.) Dowels have a tendency to rotate slightly when cut with a miter saw, which can lead to uneven or scorched cuts, so use a cradle that securely holds the workpiece. We built ours by cutting a V-shaped channel into a scrap piece with a table saw. To cut small parts safely, hold the longer waste side of the dowel and trim off the finished part **[1]**. Never attempt to cut anything less than 6 inches long as this can cause the blade to launch the workpiece like a missile.

Use a drill press to bore a 5⁄32-inch hole through the center of each part. Prevent the drill bit from wandering by first marking the center of each part with a center punch. To ensure the part is positioned perpendicular to the drill bit, hold it against the square end of a scrap piece before tightening the hand-screw clamp or drill-press vise **[2]**. Finish the parts by rounding their edges with sandpaper.

Feet

Using either a drill press or a cordless drill fitted with a ¾-inch Forstner bit, bore a ⅜-inch-deep hole in four 1⅛-inch balls. To keep the balls from moving as you drill them, clamp them within custom-made cauls fashioned from scrap pieces with ¾-inch holes bored in them **[3]**. Ease over the edges of the holes to prevent them from marring the ball's surface.

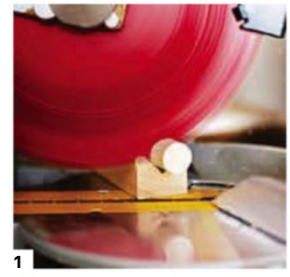
Head and Muzzle

Make the head in the same way you did the feet, but add another hole for the muzzle. Next, with the part still in the vise, bore a 5⁄32-inch hole that connects the centers of the two ¾-inch holes. Add ⅛-inch holes for the eyes. For the muzzle, bore a ½-inch hole about ⅛ inch deep into the ¾-inch ball.

Body Sections

Cut two leg sections, each 1½ inches long, from the 2-inch dowel. Mark the centers of the leg sockets, which are positioned halfway along the body sections and about 1½ inches apart from each other. Use a 1-inch Forstner bit to cut each socket ⅛ inch deep. Connect the centers of the leg sockets with a 5⁄32-inch hole. You'll need to bore this hole at a steep angle.

Cut the center section at 5-degree bevels on both ends. Next, drill a 5⁄32-inch hole through


1


2


4


3


5


6

A miter saw cuts faster and cleaner than a handsaw [1]. Brian LaRossa avoids marring his work by using a wooden clamp [2]. The author prefers Forstner bits for cutting neat holes [3]. Here's an easy way to find the center of a dowel [4]. LaRossa creates a color palette [5]. The final step is like stringing beads [6].

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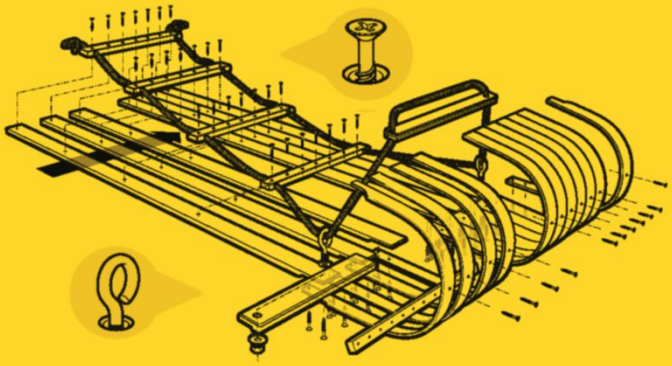
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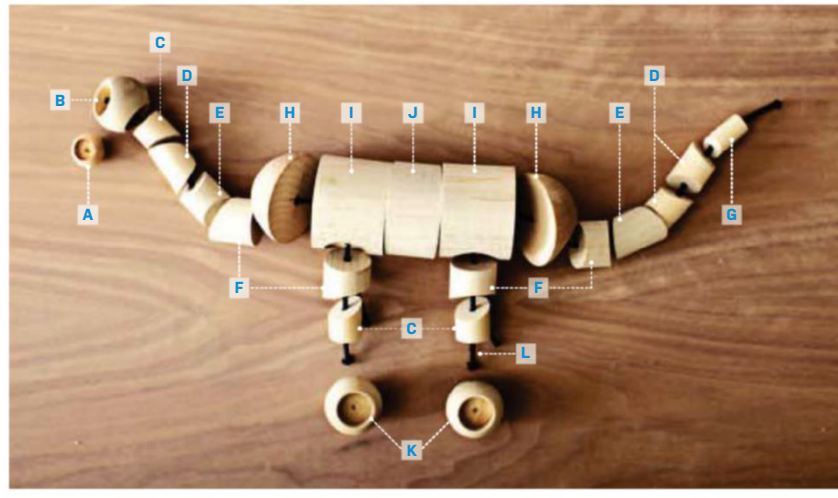
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Parts List →

Part	Qty	Name	Material	Details	Length
A	1	Muzzle	¾" ball	Bore ½" hole, ⅛" deep	-
B	1	Head	1⅛" ball	Bore two ¾" holes, ⅜" deep	-
C	5	Neck/leg termination	¾" dowel	Cut 25-degree bevel on one end	¾"
D	3	Small neck/tail piece	¾" dowel	Cut 25-degree bevel on both ends	1¼"
E	2	Medium neck/tail piece	⅞" dowel	Cut 25-degree bevel on both ends	1⅛"
F	6	Neck/tail/leg to body	1" dowel	Cut 25-degree bevel on one end	1"
G	1	Tail termination	½" dowel	Cut 25-degree bevel on one end	1"
H	2	Body end	2" split ball	Bore a 1" neck socket, ⅛" deep	-
I	2	Body (leg section)	2" dowel	Bore two 1" leg sockets, ⅛" deep	1½"
J	1	Body (center section)	2" dowel	Cut 5-degree bevel on both ends	1"
K	4	Foot	1⅛" ball	Bore one ¾" hole, ⅜" deep	-
L	1	Cord	⅛" heavy round elastic	Cut 16" for body, 8" for legs	32"

the center of each body part. To find the center, take a 1-inch-wide piece of scrap—half the diameter of the dowel—and position it against the toy part. Make a mark, turn the part about 90 degrees, and make an intersecting mark **[4]**.

Body Ends

Secure a 2-inch split ball in a hand-screw clamp or bench vise. Create the neck socket with a 1-inch Forstner bit. Position the bit so its edge is ⅛ inch from the edge of the part, and cut the hole ⅛ inch deep.

Find the center of the flat side of the split ball and bore a 5⁄32-inch hole at an angle so that it exits through the center of the neck socket.



Adding Color

Stain your toy with food coloring, which is nontoxic and can be mixed to create custom shades. Apply with a paintbrush and wipe off any excess with a rag **[5]**. Note that water-based finishes swell the parts, making them difficult to fit, so let everything dry overnight before assembling. For added luster, wipe on food-grade beeswax with a rag. Avoid waxing areas that will be glued as this will prevent a good bond.

Assembly

Using a utility knife, cut a piece of elastic cord 8 inches long and knot one end. Pass the cord through one set of leg parts, a body section, and the opposite set of leg parts **[6]**. Pull the cord as tight as it will go, and tie it off. Trim off any excess. Cut another piece of elastic cord 16 inches long, and knot one end. Thread it through the head, the neck parts, the body parts, and the tail parts. Pull it tight and tie it off. Trim excess cord from the head, but leave an inch at the tail.

Drip PVA glue into each foot's socket and attach the feet to the legs. Glue the muzzle so that its hole is positioned over the knot.

WARNING: *This toy has small parts that can be a choking hazard, so we don't recommend it for children under 3 years of age. As with all handmade toys, don't leave your child unattended with it—and if it breaks, be sure to scoop up all the parts.*



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PHOTOGRAPHS BY **GREGG DELMAN**

Tool Test

BENCH GRINDERS

The bench grinder may seem obscure, but it's the centerpiece of many well-equipped workshops. Consisting of a motor with a spindle at each end, these machines allow you to mount a wheel to grind, buff, or wire-brush metal. We gathered six grinders that all take a 6-inch-diameter wheel, and we used each to grind metal with its stock wheels and also swapped in a high-performance wheel from Norton Abrasives. In each case we recorded how much time it took to remove ⅛ inch of mild steel. We learned that switching wheels is a neat way to boost grinding performance, especially on inexpensive machines. That's good news for thrifty tool shoppers. *BY ROY BERENDSOHN*

BEST OVERALL



BALDOR
600E

RANKING ★★★★★

Price: $275

Amps: 3.1

Horsepower: 0.33

Stock wheel test: 24.16 sec.

Norton wheel test: 10.59 sec.

Likes: It's easy to forget just how good American-made equipment really is. Then you run the Baldor, and you remember what this country's products can be. It's beautifully made with large cast-metal wheel housings and it runs without vibration. Also, it's extremely powerful for a machine its size. Baldor, take a bow.

Dislikes: It could use housings that are easier to remove for swapping wheels.



CENTRAL MACHINERY
37822

RANKING ★★★

Price: $45

Amps: 3.5

Horsepower: 0.5

Stock wheel test: 178 sec.

Norton wheel test: 60 sec.

Likes: A three-star rating signifies "provides adequate performance," but this doesn't tell the whole story. Note that CM's machine did three times better when we swapped in a Norton wheel. We also liked its gooseneck lamp and the wheel covers that go easily off and on.

Dislikes: This machine arrived with sharp edges on its base, which is kind of ironic. Better deburring is needed.



CRAFTSMAN
21154

RANKING ★★★★

Price: $130

Amps: 2

Horsepower: 0.20

Stock wheel test: 51 sec.

Norton wheel test: 24 sec.

Likes: This grinder has large tool rests, a speed-control dial, a large quench tray, and a big gooseneck work light. "Every grinder should come with a wheel-dressing tool, like the Craftsman," commented tester and contributing editor Joe Truini. "It's important to keep the wheel dressed [surfaced] so it grinds quickly and with the least amount of heat."

Dislikes: None.

DEWALT
DW756

RANKING ★★★★

Price: $95

Amps: 4

Horsepower: 0.62

Stock wheel test: 29 sec.

Norton wheel test: 33 sec.

Likes: The DeWalt was one of two grinders that didn't see any improvement in speed with a Norton wheel, indicating that it comes with pretty good wheels to start with. We also liked its large, smooth tool rests and the stout, vibration-resistant mounts that hold the eye guards.

Dislikes: The wheel covers are held together with small Phillips-head screws that are difficult to remove.

JET
JBG-6A

RANKING ★★★★½

Price: $170

Amps: 5

Horsepower: 0.5

Stock wheel test: 21 sec.

Norton wheel test: 29 sec.

Likes: The Jet comes with good-quality wheels (see time trial) and a big honking motor that provides super smooth and reasonably fast grinding ability. Also super are its 3/16-inch-thick eye shields that measure 3 7/8 x 5 5/8 inches. "Now that's protection," Truini quipped.

Dislikes: It's powerful and smooth, but not as fast as we thought it would be, given its amperage.

SKIL
3380

RANKING ★★★½

Price: $50

Amps: 2.1

Horsepower: 0.33

Stock wheel test: 64 sec.

Norton wheel test: 42 sec.

Likes: The Skil was the only grinder equipped with LED-lit eye shields. It's a clever, unobtrusive way to light the work area without adding extra heat or glare. Additionally, the tool is a good and very basic grinder.

Dislikes: Could use a bit more power.

PHOTOGRAPH BY **REED YOUNG**

Home Clinic

BY ROY BERENDSOHN AND DAVID AGRELL



Fastening to Concrete The Easy Way

I got a good deal on some industrial-duty steel shelves that I plan to install in my garage. The mounting instructions call for screwing or bolting the shelves to a concrete floor and wall, but they don't say how. Any advice?



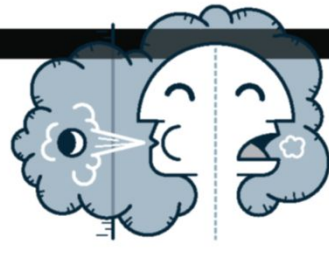
We suggest using hexhead concrete screws, which are sturdy enough for this type of application and are easy to install. They don't require the use of additional plastic or metal anchors, so there's little more to do than drill, clean, and drive.

First, start with a good-quality fastener, such as a ¼-inch Buildex Tapcon (above) or Simpson Strong-Tie Titen screw. To figure out the correct fastener length, add an inch to the thickness of the item you wish to mount. "It's extremely important to choose the right length of screw, since much of the fastener's strength is derived from how deeply it's embedded," says Chris La Vine, a senior engineer with Simpson Strong-Tie. However, more is not necessarily better. Increased depth can lead to installation issues, such as stripped fasteners and difficulties boring holes. In your situation you shouldn't need fasteners longer than 1¼ inches. "Increasing the depth of the hole to 1½ inches invites problems, especially in concrete that has a high compressive strength [over 5000 psi] or is composed of hard or large aggregate," La Vine says.

You're almost ready. Assemble the shelves and position them. Drill through a couple of mounting holes into the concrete using a hammer drill and masonry bit. Be sure to use the bit size specified by the fastener manufacturer. Most ¼-inch fasteners require a 3/16-inch bit, and oftentimes the correct bit comes bundled with the fasteners. Also, the bit has to fit through the mounting hole without hitting metal. If you need to enlarge the holes to fit the drill bit, be careful not to remove too much metal and weaken the shelf. And use a bit for drilling metal, not a masonry bit.

Make each hole just a fraction deeper than the length of the embedded fastener, depending on the directions for the screw. Once you're finished drilling,

DON'T BE AN IDIOT



We've all done it: Having drilled a nice, clean hole in concrete, we lean over and blow out the debris—with our mouths. That fine, toxic dust has nowhere to go but straight into our eyes, nose, and mouth. There's a better way: Clean it out with a vacuum cleaner. If that's not practical, blow it away with compressed air or even an old turkey baster. Just remember to keep your face at a safe distance. And always wear eye protection.

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clean the dust from the hole (see "Don't Be an Idiot"). Concrete fasteners can't develop their rated strength when they're driven into debris-filled holes.

Drive these initial mounting screws carefully with a cordless drill. Once the shelf is secured, bore the remaining holes, and drive the rest of the fasteners. Make sure you don't overtighten, which can cause them to strip out. Check the torque specified by the manufacturer; for example, a ¼-inch Titen HD Mini requires only 15 foot-pounds of torque to be tightened when driven into concrete, and 10 foot-pounds when driven into hollow concrete block.

Cranky Snowblower

We're expecting lots of snow this month, so I figured I'd pull my blower out of storage early to make sure it started. It didn't, even though it worked fine last winter. What's wrong?

You're not the only one struggling to start up your blower. In fact, outdoor-power-equipment manufacturer Ariens Company of Brillion, Wis., receives about 8000 calls a month this time of year from customers who can't start their machines. "The key to an easy start is putting the machine into storage properly," says Ariens's product support manager, Dave Miller. That means storing it at the end of the season with the fuel tank full of fresh, stabilized gasoline. (For advice on dealing with E10 and E15 fuels, see Home Clinic, November 2013.)

Whether you did that or not, now is the time to give the engine a tuneup: Change the gear and crankcase oil, grease the fittings, check the tire pressure, and change the spark plug. It's also worth reviewing the proper start sequence, Miller says. The

TOOLS & TECH

GE 60-WATT-EQUIVALENT BULBS

On Jan. 1, 2014, manufacturers will stop producing 60- and 40-watt incandescent lightbulbs in order to comply with the Energy Independence and Security Act, which requires household lighting to be 27 percent more efficient. The typical American home contains more than 40 standard lightbulb fixtures, so a lot of homeowners are not too happy about the legislation. However, there is a benefit to doing a complete changeover: You'll save an average of $143 per year on your electric bill. We spoke with GE, one of the world's largest lightbulb manufacturers, to learn more about your choices.

HALOGEN

PRICE: $3 EACH

CONSUMES 43 WATTS



Why We Like It

Like traditional incandescents, halogens instantly produce warm light and are dimmable. That's because, technically, they *are* incandescents. The difference is halogens contain a gas that allows them to burn brighter, so they can be made smaller to use less energy. GE expects eight of 10 customers to switch initially to halogens.

Downside

Halogens get very hot, so stay clear of fixtures. That also means it'll take extra energy to cool your home.

CFL–HALOGEN HYBRID

PRICE: $5 EACH

CONSUMES 15 WATTS



Why We Like It

GE's Bright From the Start bulbs contain both a compact-fluorescent-lamp (CFL) coil and a miniature halogen lamp. The halogen provides warm, even light until the CFL coil reaches full brightness, at which point the halogen switches off. CFL bulbs last up to 15 times longer than incandescents, so cost savings over time can be significant.

Downside

GE's hybrid CFLs are not dimmable. All CFLs contain mercury, a pollutant. For disposal info, visit epa.gov/cfl.

LED

PRICE: $14 EACH

CONSUMES 11 WATTS



Why We Like It

Contrary to popular belief, LEDs are neither ugly nor expensive. Well, they're not ugly. GE's Energy Smart LEDs look and feel more like your old incandescents, right down to the shape. Plus, the vast palette of LED colors available allows GE to imitate its traditional Reveal and Soft White hues. LED bulbs can last up to 14 years with typical use.

Downside

Up-front cost is high. However, prices will plummet as demand increases and manufacturing is streamlined.

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choke should be closed, the ignition switch on, the fuel valve open, and the carburetor primed. "If the machine starts but stumbles, don't turn it off," he says. "Run it out." This burns off stale gas and helps the engine pull in fresh fuel.

Ceiling Cracks

When the weather cools, cracks appear where our walls and ceiling meet. This only happens in the rooms upstairs. What's going on? More important, can I fix it?

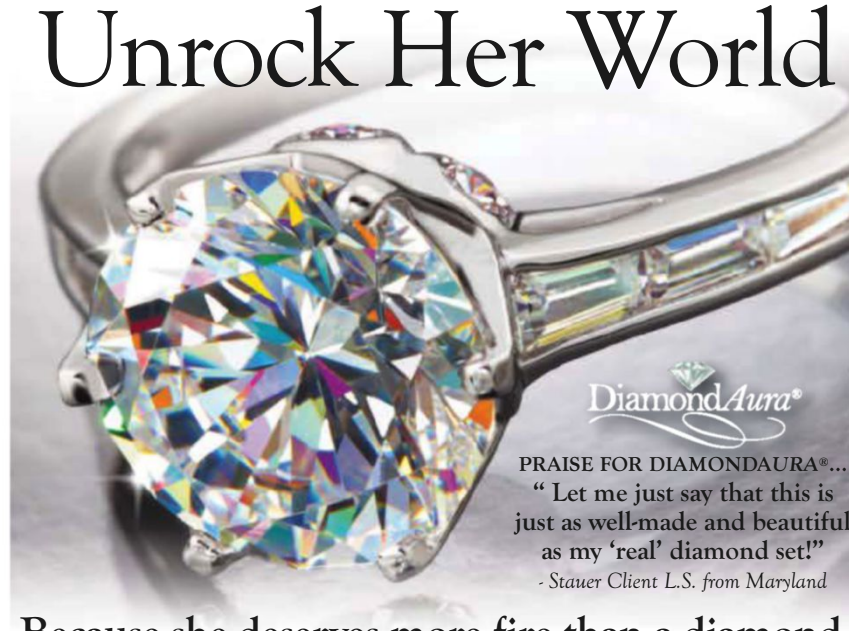
Your home is experiencing what's called truss uplift. In the winter, your home's trusses—the structures that support the roof—absorb moisture inconsistently. The members closer to the cold, damp roof deck absorb more moisture than those nearer the warm, dry ceiling. The upper parts swell and the lower parts shrink, causing the truss to bend upward slightly and lift the ceiling off the tops of the walls.

Your best bet is to install crown molding to hide the crack. Be sure to nail it to the ceiling only, and don't caulk the gap between the molding and the wall. Leave the crown free to lift with the ceiling. **PopMech**

? GOT A HOME-MAINTENANCE OR REPAIR PROBLEM? ASK THE EDITORS.

Send your questions to **pmhomeclinic@hearst.com** or to Home Clinic, Popular Mechanics, 300 W. 57th St., New York, NY 10019-5899. While we cannot answer questions individually, problems of general interest will be discussed in the column.

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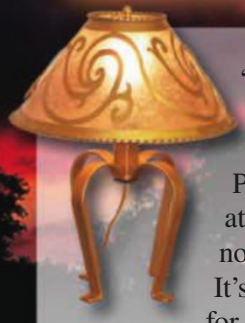


ARE WE READY FOR SMART LOCKS?

HOW TO BRING YOUR FRONT DOOR KICKING AND SCREAMING INTO THE 21ST CENTURY. *BY GLENN DERENE*

The door lock is a marvelous marriage of simplicity and complexity. Both its function (to restrict access to a building or room) and operation (insert key, twist key, open door) are simple. But it's the complex internal

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mechanics that allow the lock to work the way it does. The pins, grooves, and cylinder must all align perfectly with the proper key or the cylinder won't turn, the bolt won't throw, and the door won't open—that's the whole point. Locks have been around for thousands of years, but the modern pin-tumbler lock was invented by Linus Yale Sr. in 1848. Though the pin-tumbler is certainly pickable by an expert, the basic design has been discouraging burglars to this day.

The State of Smart Locks

Until recently, the pin-tumbler has been immune to the digital revolution. But Marc Weber Tobias, global expert on locks and physical security, notes that keypad entry and wireless locking systems have been in commercial buildings for years. Now, smart locks are finally coming to residential abodes as well. Tobias thinks the change is due to the rise of the smartphone. "In America, it's all about convenience and gadgets. If you can walk up to the door with your smartphone and touch the lock and it opens, why do you want keys?" he says. "As long as it's secure."

Most electronic locks are drop-in replacements for conventional locks, and installation is just as straightforward. Or, at least, that's what I was told. I've never installed a lock in my life, so I left that work to a professional locksmith, who installed them within minutes in the deadbolt holes in my front and back doors. My wife—who usually indulges me in my early-adopter experiments—had reservations. "If I get locked out, you'll never hear the end of it," she said.

How It Works in Real Life

The locks I had installed are Yale Real Living electronic deadbolts, from the same company founded by Linus Yale Jr. and Henry Towne in the 19th century. Other residential digital locking systems are available from Schlage and Kwikset as well as startups August, Goji, and Lockitron (see "Digital Deadbolts"). Since locks are as much a matter of home decor as of home security, the hardware comes in a variety of finishes and styles. The first generation of digital locks had hard-key pushbuttons, but the current, second-generation electronic deadbolts typically use illuminated touchscreen

KNOW YOUR STUFF

DIGITAL DEADBOLTS

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ICONS BY MARTIN LAKSMAN

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Reported by J. Page

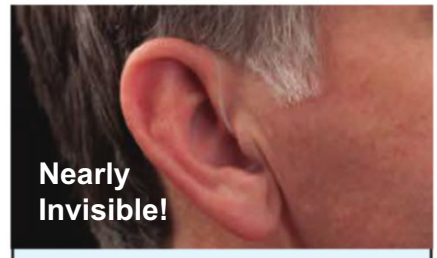
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New Digital Hearing Aid Outperforms Expensive Competitors

This sleek, lightweight, fully programmed hearing aid is the outgrowth of the digital revolution that is changing our world. While demand for "all things digital" caused most prices to plunge (consider DVD players and computers, which originally sold for thousands of dollars and today can be purchased for less then $100), yet the cost of a digital medical hearing aid remained out of reach.

Dr. Cherukuri knew that many of his patients would benefit but couldn't afford the expense of these new digital hearing aids. Generally they are *not* covered by Medicare and most private health insurance.



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- ✓ **3 programs and volume dial to accommodate most common types of hearing loss even in challenging listening environments**

The doctor evaluated all the high priced digital hearing aids on the market, broke them down to their base components, and then created his own affordable version—called the MDHearingAid® AIR for its virtually invisible, lightweight appearance.

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Can a hearing aid delay or prevent dementia?

A study by Johns Hopkins and National Institute on Aging researchers suggests older individuals with hearing loss are significantly more likely to develop dementia over time than those who retain their hearing. They suggest that an intervention—such as a hearing aid—could delay or prevent dementia by improving hearing!

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"I would definitely recommend them to my patients with hearing loss" —Amy S., Audiologist, Munster, Indiana



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keypads or wireless connections to a smartphone or key fob. Some have a redundant key-in cylinder, some do not.

The "handsome styling" of these digital locks refers to the keypads on the outside of the door—because on the interior side, the lock is a large, ugly brick that houses the electronics, a motor drive system, and a battery enclosure. The batteries inside my units were four alkaline AAs that the company claims last about a year, and, since nobody wants to be locked out of their house because of dead batteries, the locks also have an indicator that warns you when the power dips low.

The Yale Real Living deadbolt is programmed with a master code, with which you can create up to 250 four-to-eight-digit codes. When you leave the house, you push your palm to the touchscreen and the door locks automatically. To get back inside, press your palm to the screen to see the numbers, then type your code and the door unlocks—no key required. (Wireless locks such as Kwikset's Kevo, August, Goji, and Lockitron require that you bring either a smartphone or a key fob.) Guests, babysitters, contractors, and relatives can each get a separate entry code, which can be erased at any time using the master code.

Home Automation

Things get interesting when you link your lock to the rest of your home. Digital locks from Yale and Schlage can be purchased with integrated ZigBee or Z-Wave wireless antennas, allowing them to work with a home-control service such as ADT, Alarm.com, AT&T Digital Life, or Vivint. These integrate thermostats, lighting, surveillance cameras, security systems, even garage doors into Web-based interfaces that let you monitor and control every aspect of your house, from the inside or halfway around the world.

In addition to living with the Yale electronic locks, I signed up for a trial with Alarm.com to see how well the two systems worked together. An installer connected my locks to a control panel, then set up some motion sensors and cameras. He showed me how I could unlock the doors remotely from my smartphone, or configure alerts to ping my device when the door had been opened. The cameras could even snap the visitor's photo. Shortly after the installer left, my wife unplugged the cameras. "I'll live with the digital locks," she said. "The cameras are just creepy."

In practice, having an electronic door lock means you can walk out of the house without keys and still lock the door since the key is, essentially, in your head. It's surprising how quickly you get used to it—I now carry my car keys, wallet, phone, and nothing else. But the flip side of the key-as-information paradigm is that information is infinitely replicable and easy to distribute. Anyone who learns a code can gain access to your home. I still refuse to share one with my 4-year-old son because I'm convinced he would blab it to anyone who asked. Plus, the bad behaviors that make passwords vulnerable on the Internet now suddenly apply to my house. When I tried to create a password for one visitor, she started to write it down. "Don't do that," I said. "I'd rather you pick something you can remember." So she picked the alphanumeric keys that spell her child's name. "That's a terrible passcode," I said in frustration. "But that's what I use with my bank," she replied. Ugh.



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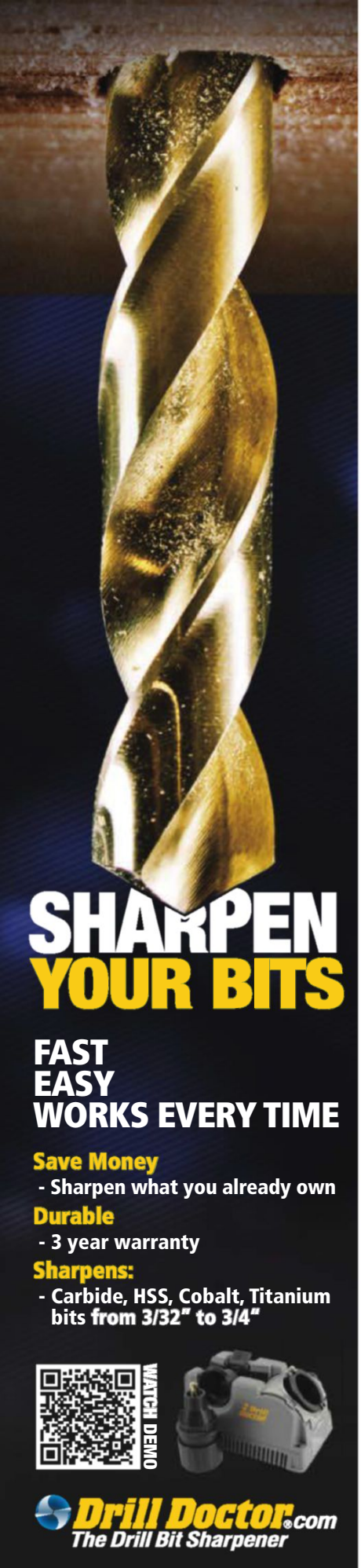






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The Difficulty With Digital Locks

The first thing everyone asks when they see a digital lock is "Aren't you afraid some hacker is going to break in?" But that's the wrong question. While it's true that digital systems are vulnerable to attack—especially those linked to a Web-based account—hacking my electronic lock still requires considerably more effort than picking a conventional lock. Or just smashing the window next to my door. Tobias, who breaks into locks as a consultant to major lockmakers, says he has concerns about the security of electronic locks that use wireless protocols, but he believes many are more vulnerable to physical attack. He has already demonstrated how he can break into Kwikset's Kevo lock within 15 seconds. "Security isn't just one thing," he says. "I don't care what kind of lock you have, my advice is to get a good alarm system." The unfortunate truth is that all residential door locks are deterrents—not guarantees of safety.

Then there are the unexpected surprises. Shortly after the Alarm .com installer left, I tried entering new user codes into the lock, which didn't work. What gives? I thought. Turns out that wireless control of the locks requires you to input all user codes through the Alarm.com interface, rather than directly into the locks. Then I moved the control panel to a more convenient location and it lost all communication with one of my locks. This, I learned, can be an issue with Z-Wave devices, which work as a mesh network—bouncing a signal from one device to the next. When you change the location of one node of the network, you can disrupt the signal transfer, and any devices that have dropped out need to be rediscovered. Since the effective range of each node on the network is relatively short, you must either install repeaters or move your control panel around the house until you find that perfect spot where it can see all your Z-Wave devices—and hope that spot isn't the bathroom shower stall.

In my three-month experiment, I also discovered one little glitch that Yale obviously didn't build a contingency for. One day I came home to find my front-door lock completely dead. What happened to the battery warnings, I wondered? Luckily, I was able to gain access through the back door, which still had a functioning lock. When I got to my front-door lock and opened its battery compartment, I discovered the problem: One of the batteries had burst and was leaking potassium hydroxide electrolyte—a relatively common occurrence with alkaline batteries. This gave the lock no way to indicate a low-battery state. I also had a redundant key, but had stopped carrying it by then—good thing I've got two doors.

Worth It or Not?

These obstacles aside, living with digital locks was a liberating experience. Some adjustments were needed to get the Z-Wave equipment working properly, but now it's operating reliably. I had to clean the caustic mess from that burst battery, but fresh Duracells fixed it up in a few minutes. For sure, there are issues that can and should be addressed. But the key-free lifestyle is so convenient that even my lock-Luddite wife has come around. After my experiment was completed, I offered to dismantle the system and replace it with our old, conventional locks. Nope, she said. She'd come to appreciate the electronic system. Besides, neither of us has any idea where our old keys are.

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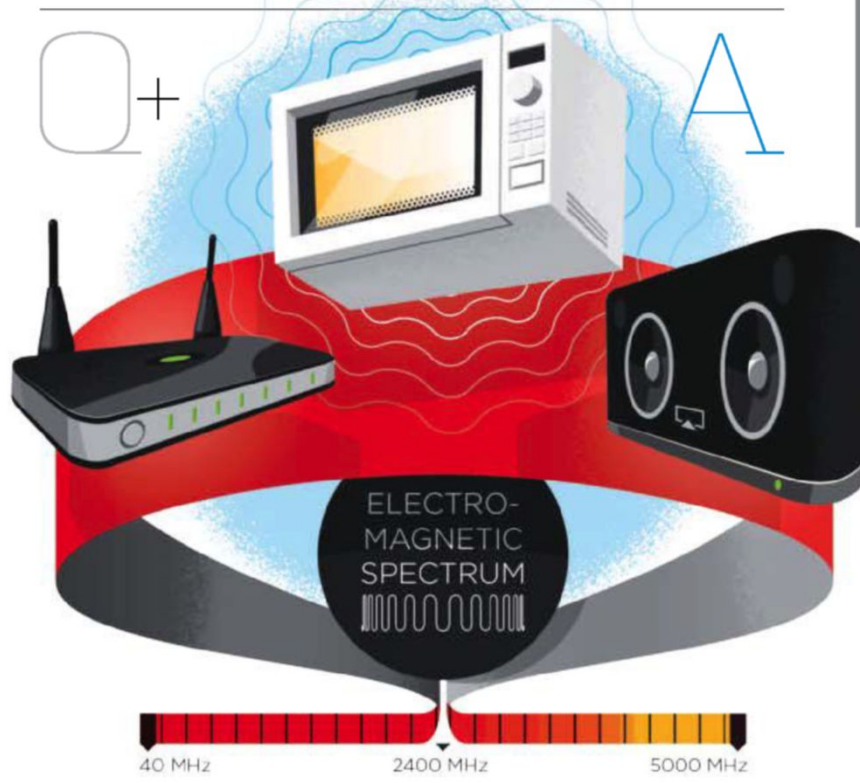
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Digital Clinic

BY RACHEL Z. ARNDT | ILLUSTRATION BY PATSWERK



Signals Crossed

Whenever I turn on my microwave, my AirPlay speakers cut out. Coincidence?

Probably not—your microwave is the likely culprit. Because AirPlay speakers receive signals over a wireless network, they're susceptible to interruptions from other electronics. And most microwaves and wireless signals operate in the same part of the radio spectrum, 2.4 GHz for routers and 2.45 GHz for microwaves. Though the majority of a microwave's energy is kept bouncing inside the box's metal walls, a tiny bit can get out. Even that bit can interrupt a wireless signal, which is beamed at about 28 milliwatts, a sliver compared with a microwave's 1000 watts. "An analogy would be having a conversation with a soft-spoken person in a crowded room," says Steven Spangler, professor of physics and astronomy at the University of Iowa. "You are trying to listen to the faint signals from the person with whom you want to talk, but it is being drowned out by the loudmouth a few feet away. It is hard to detect a signal in the presence of

large, variable noise."

The easiest solution is to move your router and speaker at least 10 feet away from the microwave. But if that's not possible, and if you own a non-AirPlay speaker plugged into an AirPort Express, you can try a dual-band router, which can transmit in either 2.4 GHz or 5 GHz. Simply have the AirPort Express operate at 5 GHz so that it's occupying a different part of the spectrum. Finally, if you don't want to pony up for a new dual-band router, you can try changing the settings on your existing one. Access your router's Web page (usually you can find this by typing 192.168.1.1 into a browser) and adjust the settings for the router's Wi-Fi channel based on the frequency of your microwave, which probably is listed in a label on its back. For example, channel 11 puts a router at 2.462 GHz, and channel 1 at 2.412 GHz—so to eliminate interference from a microwave that operates at 2.450 GHz, you'd prefer channel 1. This should fix the problem—though sometimes even devices operating in nearby channels can cause interruptions.

De-Tweeting

What happens when you block someone on Twitter? I want to block a friend who tweets at me too much and who's constantly being retweeted by others, but I don't want him to find out.

It would be very hard for someone who interacts with you a lot not to find out that he's been blocked. Once you block someone, that person can't follow you, read your tweets on his or her timeline, or put you on lists. In turn, you won't see any mentions of that person or @ replies on your timeline.

However, a block won't completely sever Twitter ties. The blocked person can still mention you and, unless your account is private, copy and paste text from your Twitter homepage to retweet it—though you'll see none of that activity if you don't visit his or her timeline.

There is a simple solution, though. Use Twitter from an app rather than the website, and then you can filter out any mentions of the person without blocking him. I like TweetDeck, an app intended for power users that can sort tweets into customizable columns. The program also allows you to "mute" tweets that match either a certain keyword (or set of words) or a username. Mute your friend and your timeline will be rid of him without any hurt feelings. **PopMech**

? GOT A TECHNOLOGY PROBLEM? **ASK RACHEL ABOUT IT.**

Send your questions to **pmdigitalclinic@hearst.com**. While we can't answer questions individually, problems of general interest will be discussed in the column.

SHIP OF DREAMS
CONTINUED FROM PAGE 93

has flown only a handful of times. Today it sits, waiting for a suitor, in a hangar at Lockheed Martin's Skunk Works facility in Palmdale, Calif. "Nobody's really built a cargo aircraft in the history of aviation," Boyd says. "What they build are people-carrying aircraft, and then they convert them to cargo." That's how Lockheed's workhorse C-130 and C-5 cargo planes got started. Now, however, airship companies are trying to convince freight carriers to take the risk.

Days after I talked with Pasternak in his Montebello office, he was on a plane. In the past few months he's been peddling his Aeroscraft everywhere from the Paris Air Show to transportation conferences in Washington, D.C., Munich, and Anchorage, Alaska. He is seeking private investors to help fund two full-size, 66-ton-payload airships; he would then spin off a separate company to lease them to private industry, just as he did with his early aerostats in the Soviet Union. The entire effort had a setback in October, when a 25-foot section of the hangar roof collapsed, damaging the prototype and delaying further test flights. Still, Pasternak predicts that by 2020 he'll have an initial fleet of 24 airships.

"What we're trying to do, we're trying to change the world completely," he says. As I listen to Pasternak, at once so eager and so patient, I can't help but ask the obvious question: People have been talking about cargo airships for more than a century. Why now? "That is very simple," he answers. "We are ready." **PopMech**

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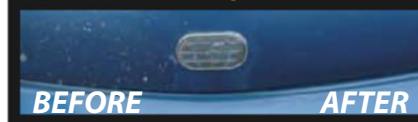
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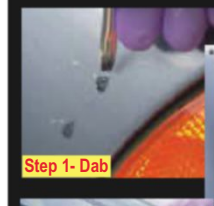
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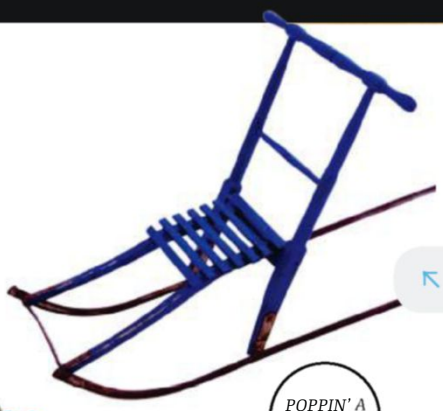
Sled

The sled helped build the pyramids, and it was all downhill from there. From ancient Egypt to modern backyards, we zip through the history of the world's most volatile vehicle. BY AMANDA GREEN



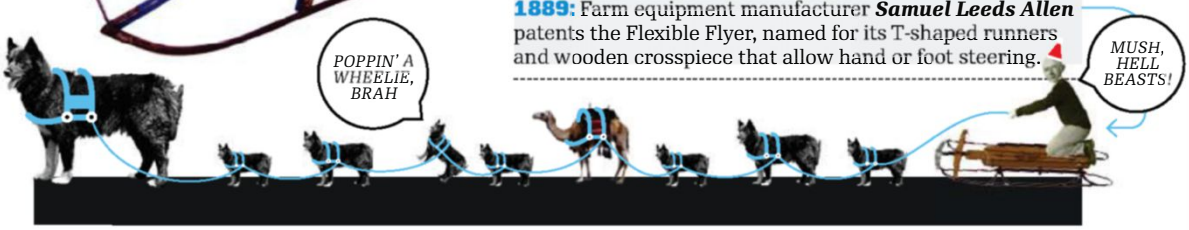
2600–2200 B.C.: Egyptians build the world's first paved road. Workers later add wooden tracks and sleds to haul stones from the quarries to early construction sites.

1822: Clement Clarke Moore captures the quintessential Santa Claus, sleigh and all, in a poem. A year later the verse is published as *Account of a Visit from St. Nicholas.*



1870: Sweden's kicksleds are like reverse mullets, with a chair-mounted party in the front and someone running in the back. Sledders eventually ditch riders and start to race.

1889: Farm equipment manufacturer ***Samuel Leeds Allen*** patents the Flexible Flyer, named for its T-shaped runners and wooden crosspiece that allow hand or foot steering.



1925: A Siberian husky named Balto and his team of sled dogs outrace a deadly epidemic in blizzard conditions to transport diphtheria antitoxin from Nenana to Nome, Alaska. Good dog!



1939: Robert L. May writes a story for Montgomery Ward to put in coloring books. It's almost cut because red noses signify alcoholism. Fortunately, Rudolph hates eggnog, or anything alcoholic, and has guided Santa's sleigh ever since.

1973: "Dog-tired" takes on a whole new meaning when 34 mushers and their canine teams trek over 1000 miles in the first Iditarod Trail Sled Dog Race. It's now the most famous sporting event in Alaska.

1989: In *National Lampoon's Christmas Vacation,* Clark Griswold coats the bottom of his saucer sled with a new noncaloric, silicon-based kitchen lubricant that creates a surface 500 times more slippery than any cooking oil.



1995: Calvin and Hobbes ride away in a toboggan—without crashing for once—in Bill Watterson's final comic strip.



2010: Rolf Allerdissen sleds down Austria's Pitztal Glacier at a record-breaking speed of 62.25 mph. *Was für ein* badass!

2012: The $2550 Snolo Stealth-X combines the mechanics of a sled and the physics of a snowboard to reach speeds of up to 40 mph. And no, you're not getting it for Christmas.

2014: At the Sochi Winter Olympics, BMW will reveal its coolest ride yet—a bobsled for the U.S. team.

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